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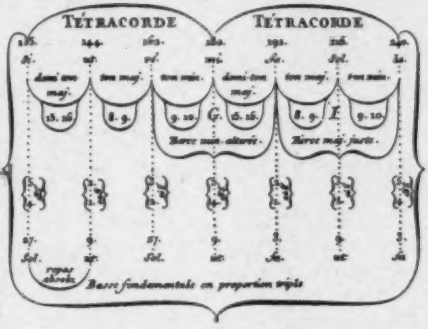

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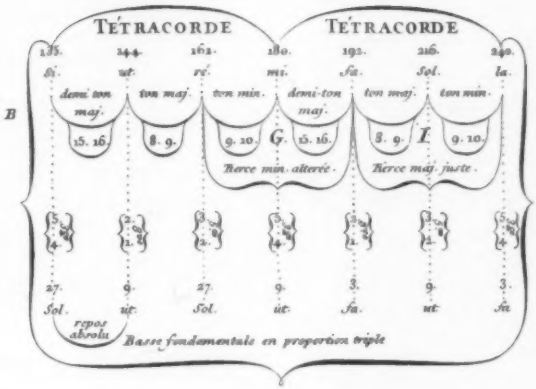

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THE PHYSICAL BASIS OF INTERVALLIC QUALITY AND ITS APPLICATION TO THE PROBLEM OF DISSONANCE

by

Richard Bobbitt
Needham, Massachusetts

A primary function of music theory is the formulation of basic concepts which will enable the student to understand more readily the essential principles of composition. Of the many problems that beset the theorist, few are more pressing than the enigma of "consonance" and "dissonance" — two words which are evidently the least understood of any in the vocabulary of music. Willi Apel notes that "no wholly satisfactory explanation and definition of consonance and dissonance has yet been found" [1, articles "Consonance," "Dissonance"], and Sir James Jeans refers to the consonance phenomenon as "one of the unsolved problems of music" [15, 156].

The writer does not propose that the line of thought pursued in this study be regarded as a panacea for the many controversies that have arisen from numerous attempts to account for the mystery of consonance and dissonance. It is hoped, nevertheless, that the observations presented here will be of value to the student who searches for more concrete channels of inquiry than are commonly offered.

The acute need for clarification of the dissonance problem is seen more clearly as we become aware of the lack of understanding on the part of various writers who have dealt with the subject in more or less detail. This is illustrated by the following commentaries, among which no general agreement exists as to the exact meaning of the terms "consonant" and "dissonant."

According to Walter Piston [21, 6-7], consonant intervals are "the perfect intervals and the major and minor thirds and sixths"; dissonant intervals are "the augmented and diminished intervals and the major and minor seconds, sevenths and ninths." As an exception, the perfect fourth is described as "dissonant when there is no tone below its lower tone," and "consonant when there is a third or perfect fifth below it." Piston then emphasizes that "the essential quality of dissonance is its sense of movement and not, as sometimes erroneously assumed, its degree of unpleasantness to the ear." Thus, in one breath, we are told that:

(1) dissonance is an inherent characteristic of certain intervals (the augmented and diminished intervals, major and minor seconds, sevenths and ninths);

(2) dissonance depends upon the response to intervallic function within a given musical situation (the "sense of movement");

(3) dissonance should not be regarded as unpleasant (although many listeners regard the atonal experiments of Arnold Schonberg — in which the "dissonant" intervals of seconds, sevenths, and tritones play a large role — as being particularly disagreeable);

(4) the dissonant quality of an interval may depend upon its position in a chord, and the same interval (e.g. perfect fourth) is therefore considered to be both consonant and dissonant!

Ernst Toch, on the other hand, tells us that "no sound, considered by itself and detached from any other context, can under any circumstances be other than neutral and meaningless... To divide any kind of sound, be it tones, intervals or harmonies, into one category of consonances per se — white sheep — and another one of dissonances per se — black sheep — is as absurd as it would be to divide the letters of the alphabet into consonances and dissonances" [29, 15]. Toch's view is generally supported by Helmholtz [13, 227-8], who says that "from the most perfect consonance to the most decided dissonance there is a continuous series of degrees, of combinations of sound, which continually increase in roughness, so that there cannot be any sharp line drawn between consonance and dissonance, and the distinction would therefore seem to be merely arbitrary ... the decision does not depend, then, on the nature of the intervals themselves but on the construction of the whole tonal system." But Helmholtz also notes that "any relation of pitch which cannot be expressed in small numbers is dissonant" [13, 331], thus completely reversing his earlier statement!

Musical consonance and dissonance are defined by Norman Cazden [7, 161] as "qualitative responses to relations among harmonic aggregates of tones within the frame of reference of a particular musical culture," and G. Révész also refers to the consonance-dissonance phenomenon as the result of "esthetic evaluation" [24, 89]. But E.G. Bugg observes [5, 17] that it is "a mistake to attempt to make the history of the art of music the basis for a scientific explanation of consonance"; and Apel tells us that "every interval contained in the major (or minor) triad and its inversions is a consonance, the other intervals are dissonances" [1, articles "Consonance," "Dissonance"], in spite of Toch's insistence [29, 12] that "in the light of light there are countless shades of shade"!

Among the theorists who adhere to the concept that an isolated interval per se may be categorized as consonant or dissonant, there are many who classify the consonances as perfect or imperfect (or primary and secondary). J. J. Fux, well-known 18th-century theorist and composer, refers to the unison, fifth, and octave as perfect, the sixth and third as imperfect; he then calls the second, fourth, diminished fifth, tritone, and seventh dissonances [11, 15]. A similar approach is used by W. J. Mitchell although, as is the case with many theorists, the Fux terminology is no longer adhered to, and the "primary" consonances now include the unison, octave, fifth, and major third. The sixths and minor third remain "secondary," while the fourth joins the secondary consonance category [19, 32]. Goetschius, however, does not hesitate to classify the unison, octave, and perfect fifth as "secondary" consonances [12, 20]!

THE PHYSICAL BASIS OF INTERVALLIC QUALITY

Again it should be evident that there is no general agreement as to the exact musical meaning of the words "consonant" and "dissonant." The foregoing quotes, in spite of many discrepancies and contradictions, are useful in that they clearly expose the nature of the dilemma. Consonance-dissonance, to some (Bugg, Apel, Fux, etc.) is seen to mean the intrinsic, irrevocable characteristics of a particular interval in isolation; while to others the phenomenon is largely a qualitative response dependent upon context (Toch, Cazden, etc.). It seems obvious, therefore, that both consonance and dissonance are commonly conceived as dualistic phenomena — i.e. they are both defined according to the following classifications:

(1) as predetermined, categorical evaluations of isolated intervallic sonorities (the non-functional approach);

(2) as qualitative responses to contextual intervallic relations (the functional approach).

Theorists who favor the non-functional classification of intervals as consonant or dissonant, regardless of context, usually make their judgements on the basis of number ratios, beating phenomena, or fusion. These characteristics, in turn, are assumed to account for various degrees of roughness-smoothness, or pleasantness-unpleasantness. Pythagoras proposed that sounds made by strings whose lengths are to each other as 1:2: 3:4, are more pleasant when heard together than sounds from strings whose relative lengths are expressed by larger numbers [23, 69]; and Jean Philippe Rameau observed [22, 5] that "the order of the origin and perfection of consonant intervals is determined by the order of the numbers" (in the natural harmonic series) — i.e. the smaller the number ratios, the greater the consonance. Many acousticans of the 20th century still adhere to the same ancient premises, in spite of the fact that the equally tempered fifth, which cannot be distinguished by ear from the Pythagorean pure fifth, is approximately equivalent to the ratio 295:442 [31, 7] — hardly a small-number relationship. F. R. Watson, for example, tells us [30, 107] that "two pure tones are harmonious and pleasing to the ear if the ratio of their frequencies is made up of small numbers."

Helmholtz, in addition to his other theories of consonance, suggests that intervals are consonant if no "disturbing" beats are produced by the two tones or their harmonics [13, 186ff], and then arranges the various intervals in "order of smoothness" [13, 193]. Otto Ortmann, however, states that "quality is a psychological reaction and has no independent physical component" [20, 3].

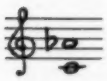
Intervallic classification according to the theory of "fusion" is chiefly the result of investigations conducted by Carl Stumpf [28], who measured the consonance of intervals according to their tendency (to the trained ear) to fuse together as a tonal unit (klang). Stumpf, in direct contrast to Ortmann, did not feel that the smoothness, or blending quality, of certain intervals was explainable on psychological grounds. It was his opinion that "the cause of fusion is a physiological one ... the nature of the situation indicates that it is an aspect of feeling, a relationship inherent in the simultaneous tone-qualities, and in-

dependent of individual experience. The relationships of feeling, like feelings themselves, are not based on underlying psychological causes but only on physical ones" [28, 2:211]. Révész, however, maintains that the blending quality of the octave, for example, is a result of "phenomenological similarity," not of fusion [24, 61].

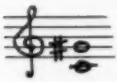
The result of these many irreconcilable viewpoints is, of necessity, complete and thorough confusion. The issue, however, remains clear. Are we to regard consonance and dissonance as non-functional intervallic sonorities with varying degrees of "roughness" or "smoothness," or do we consider them to be qualitative responses to functional musical situations? To continue the dualistic description of consonant and dissonant intervals can hardly contribute to the growth of music theory as a practical science. Consonance and dissonance should not be used to describe both functional and non-functional situations.

Surely, it borders on the ridiculous to tell a student that isolated intervals may be classified a priori as consonances and dissonances, and then to declare that a dissonance is really nothing but an interval which must "be followed by another harmony, without which the effect would be unsatisfactory and incomplete" [25, 16]. According to the rule just stated, any interval might be "dissonant" in function if it seemed to require resolution and, if such be the case, why bother to categorically label every interval as consonant or dissonant? Imagine the student's confusion when he is taught [25, 17; 20, 6] that the interval in Ex. 1 is consonant, but that the interval in Ex. 2 is dissonant!

Example 1.



Example 2.



The usual explanation, of course, is that the augmented fifth has a tendency to resolve upward, and that this "leaning" towards resolution conveys an impression of incompleteness (and consequently, dissonance) to the ear. Is it not equally logical, however, to assume that the minor sixth also could have a tendency to resolve downward (e.g. IV^{6}_{4} — I in c minor), and that such a tendency toward resolution would demand that it, too, be classified as dissonant? The same reasoning applies to all intervals, since any interval may be spelled enharmonically.

Semantic dualism of this nature can only produce connotative contradictions which add fuel to the controversy and offer little in the way of a solution. It is no longer possible, for example, to appreciate the meaning of music critics when they make statements similar to the following:

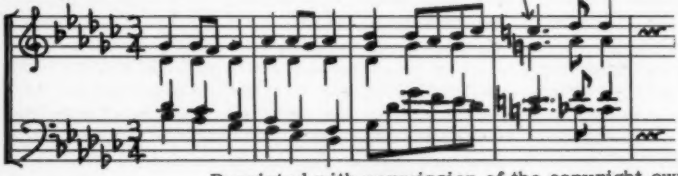
> Herr Von Einem opens with a movement marked Maestoso. It begins with a series of brass fanfares of dissonant nature contrasted with string passages of consonant nature.[1]

1. From an article by Harold Rogers (Christian Science Monitor, Oct. 12, 1957) on the Symphonic Scenes for Orchestra, Opus 22, by Gottfried von Einem.

Does the writer mean that the brass fanfares consisted of many so-called "dissonant" intervals of seconds, sevenths, and tritones which disturbed him because of their roughness, or is he merely implying that the passages for brass were loud and strident in contrast to the lower decibel output of the strings? Or, on the other hand, was he perhaps aware of certain disturbing contextual intervallic relationships in the brass which — due to imbalance or obviously inappropriate distribution — caused a disturbing psychological response as opposed to the perhaps logical intervallic texture of the string passages? Because of the present confusion in terminology, we actually have no way of knowing whether the critic was describing a qualitative response to contrasting functional intervallic situations, or whether he was simply referring to the apparent roughness (or lack of it) of isolated chord-structures. We can not know for sure since the words "consonant" and "dissonant" have no generally accepted meaning.

The problem, therefore, is obviously one of semantics, and the solution does not hinge upon the question as to which isolated intervals shall be termed "consonant" or "dissonant," but upon the decision as to the exact meaning of the words themselves. We may regard consonance and dissonance as words which describe non-functional, individual intervallic structures, or as words which express the listener's response to functional musical situations. But the non-functional approach can hardly meet with any more success in the future than it has in the last 2500 years, since any interval can be made to sound "out-of-place" or "off-balance" by creating an intervallic or rhythmic texture which deliberately exposes the interval or chord in an awkward manner. Among the many available illustrations, the following by Ernst Toch [29, 12] is particularly effective:

Example 3.



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Observe how the dissonant major triad in m. 4 finds no repose in itself, but demands resolution into the following 7th chord! This in spite of the fact that the C-major triad is made up entirely of so-called "consonant" intervals, and that physicists tell us "to learn whether a triad is consonant we examine the intervals that form the triad" [16, 53].

Webster defines musical consonance as "a combination of tones giving a sense of repose, not requiring resolution" and the adjective, "consonant," is shown to mean "consistent" or "compatible." These terms appear to be quite adequate for the description of qualitative responses to functional musical situations and, in view of the obviously irreconcilable contradictions of the non-functional approach, it would seem advisable to use the expressions "consonant" or "dissonant" only

when referring to an individual's psychological response to contextual situations.

Studies in music theory should no longer use the terms "consonance" or "dissonance" when describing the quality of isolated, non-functional intervals. Both words are extremely useful when confined to functional situations, but their non-functional use has contributed little or nothing to the clarification of theoretical problems. The above principles, therefore, will be adhered to throughout the remainder of this study, and consonance or dissonance, as such, will not be used in any other context than the following definitions suggest:

Consonance — a functional combination of tones which stimulates — within the individual — a sense of repose, relative stability, and equilibrium.

Dissonance — a functional combination of tones which stimulates — within the individual — a sense of stress, relative instability, and imbalance.

To discontinue the use of "consonance" and "dissonance" for the description of static intervallic sonorities, however, creates an immediate need for new terminology. If isolated intervals are to be measured no longer in terms of a fictitious "consonant" or "dissonant" evaluation, how then shall we describe them?

It is quite obvious that all intervals, regardless of their musical application, do not sound alike, and some method of description must be devised which adapts itself equally well to functional and non-functional situations. As we have noted, the irreconcilable confusion concerning the meaning of consonance and dissonance makes the continued use of these words extremely impractical when applied to non-functional sonorities, but this does not mean that intervals no longer may be categorically classified as individual entities. The real need is for an indisputable scale of measurement which will aid in the evaluation of the various intervals according to their sonorous properties. Such a scale would provide a basis for the determination of potential stability-instability, simplicity-complexity patterns that occur in the evolution of vertical, diagonal, and horizontal intervallic areas. Before exploring the problem of simplicity and/or complexity further, however, let us pause for a moment in our probing for a more concrete description of intervallic sonority to consider the nature of the medium through which tones and, consequently, intervals are perceived.

The planet earth is surrounded by a gaseous envelope which exerts a pressure of about 14.7 lbs. per square inch (at sea-level) upon all exposed material objects, and it is this invisible, odorless, and tasteless mixture which transmits the pressure changes that produce the sensation of hearing in the human ear [4, 2]. These pressure changes — the result of molecular compression variations — are brought about by the agitated motion of material objects with sufficient impetus to cause a displacement of air particles [27, 455]. An object at rest,[2]

2. Properly speaking, no air particle is literally at "rest," since gaseous molecules are constantly in motion (Kinetic Theory). "State of

Diagram 1. Alternate condensation (compression) and rarefaction (decompression) of a single "stream" of air particles.

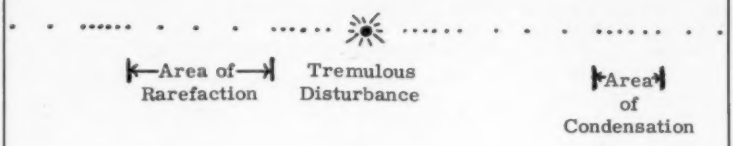


Diagram 2.

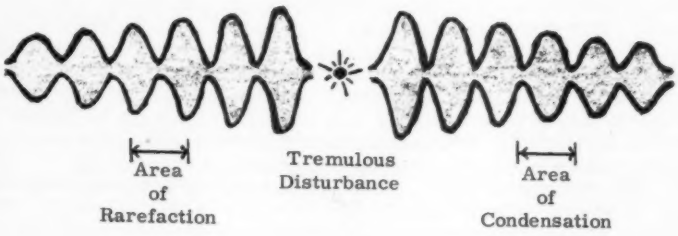
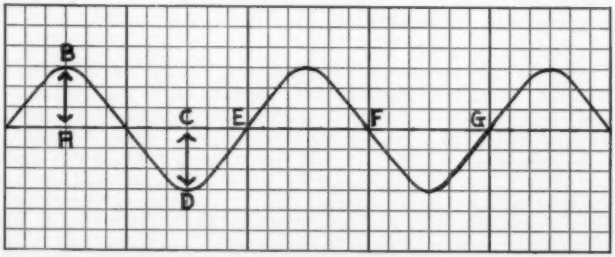


Diagram 3.



of course, will not disturb the air mass around it, but if force is applied so as to cause the object to change its spatial position, the resulting movement will act against the surrounding air particles and effect a compression of these particles. Such action produces an opposite reaction which continues until the original disturbance has dissipated, and this alternation of molecular condensation and rarefaction constitutes the phenomenon known as "vibration." Air vibrations occurring at a rate of about 16 to 40 times per second, or faster, stimulate the hearing response termed "sound."

To force a material body from a position of rest implies the tendency of this body to return to its original locus due to the pull of gravity. Also, the impulse of the disturbance gives the moving object momentum, so that it tends to pass beyond its starting position. Thus, the most important principles [4, 3] underlying vibration are:

(a) the tendency of a body to return toward its rest position if it be displaced therefrom (elasticity), and

(b) its tendency to overshoot the rest position, becoming displaced in the other direction (momentum).

In other words, once an air particle is set in motion, elasticity and momentum tend to keep it in motion until inertia causes it to return to rest. The same reasoning may be assumed to apply when a large number of particles are displaced and, of course, any vibratory pulsation in the atmosphere instantaneously involves millions of air molecules. To describe this phenomenon visually is well-nigh impossible, but the following diagrams may prove helpful. Each dot in Diagram 1 (p. 179) theoretically represents an air molecule, although a molecule of air is not only invisible, but also infinitesimal.

This type of particle pulsation is termed "longitudinal displacement" [16, 14]. It is necessary, however, that we try to visualize the pulsation pattern as simultaneously extending in all directions from the source of atmospheric disturbance. A "cross-section" of this contracting-expanding, accordion-like activity might look something like Diagram 2 (p. 179).

This type of particle pulsation is termed "transverse displacement" [17, 14], and has become the more popular method for representation of particle displacement because of its visual convenience. Again, however, it is necessary to imagine the process as a simultaneous projection in all directions. The continuum of transverse motion shown in Diagram 2 is quite similar to the form of periodic motion known as "simple harmonic motion," and the latter may be illustrated by a "simple harmonic curve" (Diagram 3, p. 179).

A simple harmonic curve is elementary, regular, symmetrical, and is an instantaneous graphic representation of the condition of motion in a simple wave [15, 12] — i.e. the distances AB or CD illustrate amplitude or intensity (the amount of particle displacement), and the distances EF or EG illustrate consecutive periods in time (the fre-

---

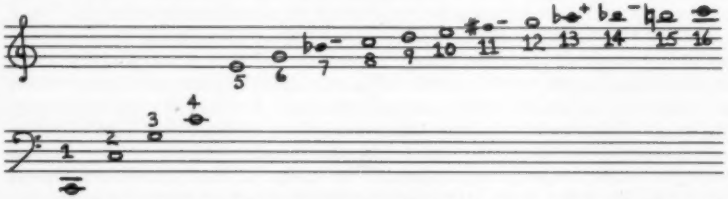
equilibrium" would be more appropriate, but the former term is employed in acquiesence to common usage.

quency of particle displacement). In other words, the simple curve in Diagram 3 represents "molecular displacement in time"; and since a vibration is considered complete when it returns to its starting point, the distance EG is termed a "phase." Thus, when we say a tone has a frequency of 440 cycles-per-second, we mean that a given pressure-wave goes through 440 complete phases of vibration in one second.

The factors of "amplitude" and "periodicity," as represented by a simple harmonic curve, are particularly important to this inquiry. But in the study of intervals we are also concerned with amplitude-periodicity relations between two or more tones, and it is necessary, therefore, to comment briefly upon the source of interval ratios.

Air columns of relatively constant density, or strings of relatively constant tension, will produce composite vibration waves which contain a fundamental, predominating tone, as well as other tones of less intensity known as "overtones." These overtones, partials, or harmonics are the instantaneous result of an infinite series of vibratory pulsations which are present with the fundamental tone. The lesser vibrations, although not easily heard as individual pitch-units, are always present with the fundamental and stand in fixed mathematical ratios to the frequency of the fundamental. Assuming the tone C to be a given fundamental, Ex. 4 illustrates the well known overtone complex[3] that sounds simultaneously with the fundamental tone.

Example 4. First 16 partials of the tone C.



By referring to the harmonic series it is seen that ratios for all of the intervals are readily available. The interval of the octave, for example, is formed by tones related as 1:2, and the fifth is seen to be formed by the ratio of 2:3. Ratios for the major third (4:5), minor third (5:6), and major second (8:9) — and for any interval — are similarly in evidence. Furthermore, since the ratio for the perfect fifth, for example, is 2:3, we know also that 200 cycles-per-second against 300 cycles will sound like a perfect fifth; 300 against 400, like a perfect fourth, and so on.

Having acquired a "speaking acquaintance" with the nature of sound and the source of interval ratios, let us return to the problem of adequate terminology to be employed in the description of static (i.e. isolated) intervallic sonorities. It is important, however, to understand clearly that the various graphic representations of wave amplitudes and periodicities are no more than rough illustrations of some of

3. Black notes indicate tones that can be identified only approximately in our present day system of equal temperament. Plus and minus signs indicate whether the tone is sharp or flat.

the more easily perceived characteristics of vibrational phenomena.

The configurational behavior of air particles in vibratory motion is extremely complex and, in addition, relatively little is known about the way in which the ear really hears. The best writers on sound and hearing (Fletcher, Stevens-Davis, Jones, etc.) have continually warned their readers against over-simplification in the analysis of acoustical situations. Pause for a moment to reflect upon the incredible number of vibrational phenomena that surround the ear during a symphonic concert. Pressure waves are transmitted from many different kinds of instruments across a large hall to the ears of listeners seated at various distances from the orchestra. These waves are subjected to reflection (by walls, floor, ceiling), absorption (by drapes, carpets, clothes of individual persons), interference (as the result of superposition of individual wave trains), and set up sympathetic vibrations within the floor, seats, walls and ceiling of the hall. In addition, the orchestra itself is actually composed of a mixture of tunings [3, 200]; in that the piano and harp are tuned in equal temperament, the strings tend toward Pythagorean intonation, and the brass plays essentially in just intonation. The listener, however, adjusts himself almost immediately to the surrounding cacophony, and accepts the result as "a good performance"!

Situations of this kind point up the marvelous ability of the ear to find a mean between extremes. Compare, for example, the aural response to vibrato, an effect produced by rapidly fluctuating between the adjacent pitches above and below a given fundamental tone. The vibrato actually produces a whole family of tones of different pitch and intensity [17, 215], and the apparent richness of vibrato is due to the presence of these tones on either side of the central pitch [4, 24]. Oddly enough, due to the ear's power of mean discrimination, vibrato does not obscure the pitch of the fundamental tone. If several tones of nearly the same frequency (e.g. 600, 604, 608, 612, 616 c.p.s.) and intensity are sounded together, the resulting tone will be judged by the ear as having a pitch which is the approximate mean of the highest and lowest extremes [4, 24]. This fact and other similar phenomena have led the writer to believe that the mean perception of pitch is the outstanding feature of the ear's ability to discriminate between manifold acoustical events.

Other characteristics of tone such as intensity, duration, quality, volume, and brightness are important; but these factors are of little consequence if the listener is unable to perceive pitch. It seems safe to assume that we are not concerned as much with how loud a tone is sounded, or how long it is sustained by a single-or double-reed instrument, as we are with its location on the musical staff. And, fortunately, the first significant musical information that the ear transmits is evidently that of pitch-identity; other factors seem to be a secondary response.

Fletcher tells us [10, 61] that the subjective phenomenon which we identify as pitch is the result of the objective stimulus, frequency. In other words, when we identify pitch we are responding primarily to an event or combination of events in the time-domain, because frequency is the result of the periodicity of wave phases. Now an isolated interval is formed by superimposing one wave-train upon another, and the result of this superposition is what we identify as an octave, fifth,

or fourth, etc. Thus, we are again faced with the necessity of deciding which aspect of the interval phenomenon is the most easily perceived by the ear and, due to its relatively constant nature, might therefore be used as a criterion for non-functional, descriptive terminology.

As noted earlier, the equal-tempered fifth cannot ordinarily be distinguished by ear from the Pythogarean fifth and, although the frequency ratio of the former is around 295:442, the aural response seems to be identical to the one stimulated by the ratio 2:3. It is evident, therefore, that the ear is able to accept the 295:442 ratio as a mean approximation of the true 2:3 ratio. If such were not the case, the practical performance of music would be impossible, since no instrument without a set tuning (e.g. keyboard instruments) can be relied upon to produce intervals which are perfectly adjusted according to the ratios of natural (just) intonation. Realistic theorists have known for years that tuning is actually a system of compromise within a particular frame of reference [3, 197-9].

The above should not be construed as an acceptance of the "small-number theory" of consonance. To demonstrate that the ear can perceive a mean approximation in small numbers between slightly mistuned intervals does not give us license to proclaim the consonance or dissonance of such intervals. To discover that two tones are related as 3:4 or 221:295, or any other ratio, does not warrant their being labeled as inherently consonant, since any interval can be forced into a situation of imbalance and thus become dissonant.

The real importance of the foregoing, to this inquiry, is that the ear's power of mean discrimination in the time-domain is as acute when perceiving intervallic relations as when identifying individual tones. It is the writer's opinion, therefore, that when we identify interval we are responding primarily to an event or combination of events in the time-domain, because interval is essentially the result of superimposed periodicities of wave phases.

Let us now examine the phenomenon of wave superposition more closely. Assume that a wave of 300 c.p.s. (wave "A") is to be superimposed against a wave of 200 c.p.s. (wave "B"). The ratio between the two frequencies will be 300:200 or, more simply, 3:2, and the auditory response will be that of a perfect fifth. At the same time, a new wave (resultant "R") is produced as the result of interference between the two superimposed periodicities. This is illustrated in Diagram 4 (p. 184) by using the simpler of the above ratios, i.e. 3:2 rather than 300:200.

Wave A goes through three complete cycles every second, and wave B goes through two complete cycles every second. A total time duration of two seconds is shown in this example so that the repetitive shape of the resultant wave can be clearly seen. It is obvious that the configurations of the resultant wave are no different during the second time-period (between one and two seconds) than the first, nor will its essential periodic shape change during subsequent time-periods.

Further, it is seen that, during the two seconds of time, the resultant wave intersects first wave B, then wave A in an unchanging, alternating pattern. These points of intersection are indicated by arrows, and the numbers between the arrows show the fractional parts

Diagram 4.

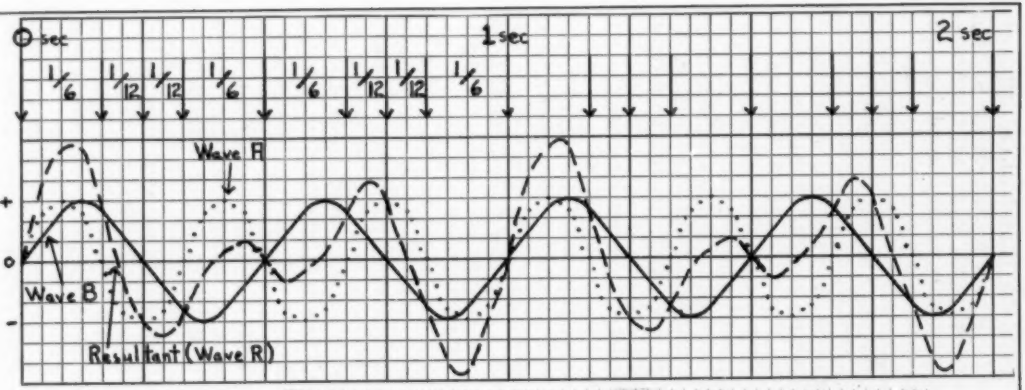
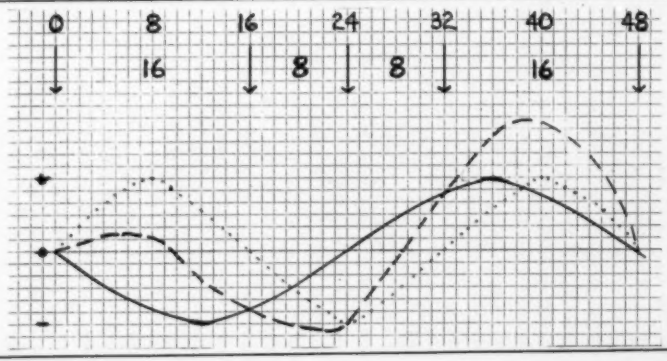


Diagram 5.



of a second which elapse between intersection points. In other words, between the first and second points of intersection there are 4 graph-units, and between the second and third points of intersection there are 2 graph-units — i.e. 1/6 and 1/12 respectively of the total number of graph-units representing one second in time. There are also 2 graph-units between the third and fourth points of intersection and 4 units between the fourth and fifth points — i.e. 1/12 and 1/6 respectively of the total number of graph-units representing one second.

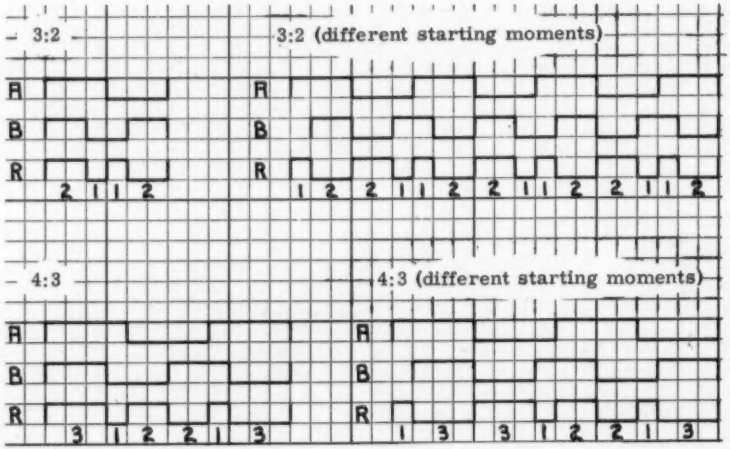
Thus, the fractional sequence of 1/6, 1/12, 1/12, 1/6 is equivalent to 4, 2, 2, 4 graph units in continual repetition or, more simply, to the proportion 2:1:1:2. The general conclusion to be drawn from these observations is that the resultant wave of 3:2 alternately "intersects" the original generating waves at temporal points which are proportionately related to one another as 2:1:1:2. The importance of these points of "intersection" is more clearly seen upon further examination of the superposition phenomenon.

Diagram 4 provides a visual approximation of what happens roughly in terms of amplitude and periodicity when two waves of different frequency are superimposed. The most obvious feature of this superposition process is that waves A and B are relatively coincident in phase at some points and almost opposite in phase at other points. They are either "adding" to one another or "subtracting" one from the other — i.e. there is a succession of reinforcements and cancellations of amplitudes. But, in contrast to the additive-subtractive aspects of superposition, there are certain points in time where no reinforcement or cancellation takes place. Such moments occur when either of the two original waves equals "zero" — i.e. when A or B crosses the zero-abscissa — and, therefore, can neither be adding to nor subtracting from the other wave.

A resultant wave provides visual evidence of these moments. The second arrow in Diagram 4, by way of illustration, indicates that point at which wave R first intersects wave B. Note that wave A, at that same moment, is just crossing the zero-abscissa and, therefore, is neither "plus" nor "minus," neither reinforcing nor cancelling. The third arrow indicates the point at which wave R first intersects A. Note that wave B, at that same moment, is also just crossing the zero-abscissa and, therefore, is neither adding to nor subtracting from wave A. The remaining arrows indicate similar time-moments. These moments, occurring in regular sequence at points periodically related as 2:1:1:2, represent fluctuations in pressure which are directly related to changes in molecular mass — i.e. any pressure fluctuation involves a displacement of air particles which, in turn, produces condensation or rarefaction in certain areas. The pressure fluctuations extend throughout the perceivable volumic area (space occupied) of the interval, and constitute patterns of variable density throughout the volumic area.

Density, as a physical phenomenon, is mass per unit-area — e.g. a cc. of wood is considered more dense than a cc. of air because the mass of the former per unit-area is greater than the mass of the latter. Pressure changes are directly related to variations in density, since fluctuations of pressure are changes in particle mass per unit-area. The writer submits, therefore, that the predominant relationship between frequencies of different periodicity is found in the time-domain;

Diagram 6.


3:2
3:2 (different starting moments)
R
B
R
2 1 1 2
1 2 2 1 1 2 2 1 1 2 2 1 1 2
4:3
4:3 (different starting moments)
R
B
R
3 1 2 2 1 3
1 3 3 1 2 2 1 3

and that this relationship is perceived as minute, rapid fluctuations of pressure, measurable in terms of time-moments resulting from waves in superposition. This phenomenon, in its broadest sense, will be regarded as intervallic density[4] — i.e. the amount of particle activity in a perceivable unit-area.

The process described in Diagram 4 may be illustrated equally well, and more simply, by utilizing only the essential features of the interference pattern. Observe that the regular sequence of time-moments periodically related as 2:1:1:2 occurs four times in two seconds. It is evident, therefore, that all subsequent patterns of pressure change are but repetitions of the events taking place in the first half-second of time. The same procedure for example, is duplicated in Diagram 5 (p. 184) by subdividing a distance of 48 graph units along the zero-abscissa into three equal wave sections (dotted line), and superimposing this tripartite division against a bifold subdivision of the same 48 units — in other words, 3:2.

The resultant wave intersects the generating waves at the points indicated by arrows, and the order of graph-units between the points of intersection is seen to follow the sequence 16, 8, 8, 16 or, as before, 2, 1, 1, 2. The most convenient visual method, however, is found in the use of so-called "square" waves, by means of which any resultant of interference may be calculated easily. Diagram 6 (p. 186) shows the result of superimposing three graph-units (wave A) against two (wave B) and, also, four units (wave A) against three (wave B). The resultant (R), in both cases, is identical to the proportions resulting from superimposed sine waves of 300 cycles against 200 cycles, and 400 cycles against 300 cycles respectively.

It is interesting to note that the starting moment of the two wave trains does not affect the overall sequence of periodic events. Even though one starts later than another, it will soon fall into phase. Interested readers may experiment with sine waves in the same manner by having either wave start 1, 2, 3, or any number of cycles before or after the other. It will be found that the two waves synchronize quickly regardless of the starting moments. By using square waves, the foregoing principles may be applied also to specific changes in amplitude level. Diagrams 4, 5, and 6 represent visually the points in time where no reinforcement or cancellation of amplitude takes place with superimposed waves whose frequency ratios are related as 3:2 or 4:3. The changes in amplitude level between these time-moments can be illustrated roughly by assigning a positive-number value to each vertical graph-unit. Horizontal graph-units are used, as before, to indicate temporal-durational periodicities.

Suppose, for example, that each vertical graph-unit, or "block," has the value of "1." Diagram 7 (p. 188) shows the resultant amplitude changes between two square waves whose periodicities are related as 3:2. Note that the resultant configuration remains at +2 for two time-units before dropping to zero for one time-unit. After dropping to -2 for one more time-unit, the amplitude pattern returns to zero for two

4. Not to be confused with Joseph Schillinger's use of the word, which he employs to describe an indefinite sense of "fulness" [26, 700]. Density, in this study, pertains to a mensurable, objective phenomenon.

Diagram 7.

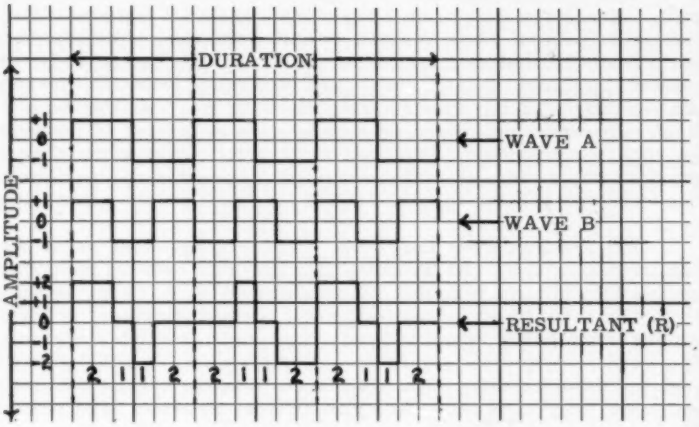


Diagram 8.

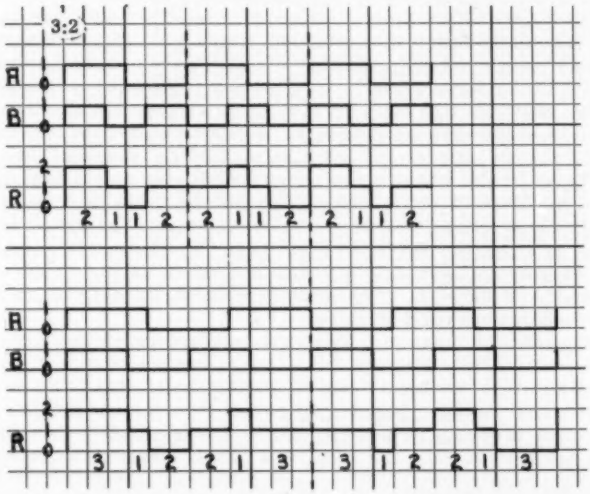


Diagram 9.

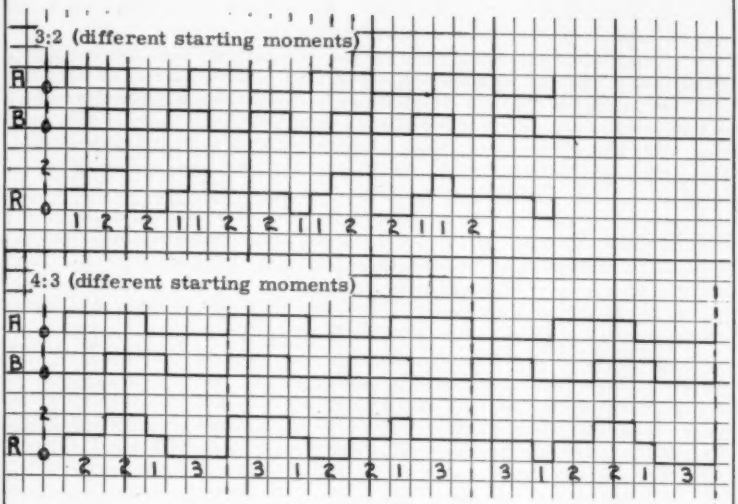
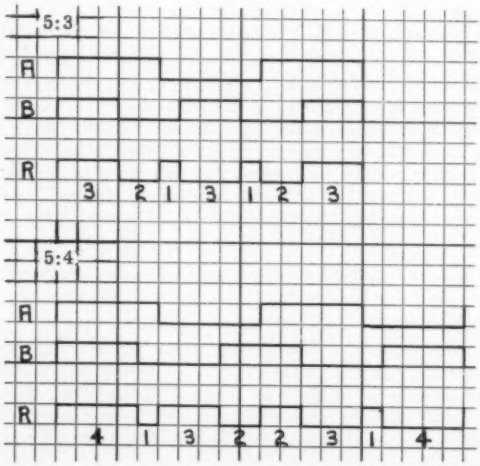


Diagram 10.



time-units. From this point on the resultant repeats itself continuously (each repetition is bracketed by dotted lines).

The same results may be obtained more simply as in Diagram 8 (p. 188), where the durational changes in amplitude level are shown for 3:2 and 4:3. Starting moments of the two wave trains will not affect the over-all amplitude change patterns. As illustrated in Diagram 9, the waves begin to synchronize almost immediately.

The foregoing examples reveal, therefore, that the additive-subtractive aspects of wave superposition yield a pattern of pressure fluctuation that is directly related to the numerical periodicities of the superimposed waves. A wave of 300 c.p.s. against a wave of 200 c.p.s. (i.e. 3:2) will produce changes in amplitude level. The approximate time-moments between these amplitude changes are periodically related as 2:1:1:2, and may be described as durational changes in amplitude level. A wave of 400 c.p.s. against a wave of 300 c.p.s. (i.e. 4:3) will produce changes in amplitude level, the time-moments between which are periodically related as 3:1:2:2:1:3 (Diagrams 6, 8). Such durational changes in amplitude (intensity) level are directly proportional to the amount of particle activity in a perceivable intervallic area, and are regarded as variations in density.

An interval resulting from 300 c.p.s. against 200 c.p.s. is consequently less "dense" than one resulting from 400 c.p.s. against 300 c.p.s., because the former excites less activity than the latter. Pressure fluctuations periodically related as 2:1:1:2 are less turbulent than fluctuations periodically related as 3:1:2:2:1:3 — i.e. the total air mass (volumic area) is less "disturbed" in the case of the former.

By using the foregoing procedures (especially the square-wave method, for simplicity), the relative amount of particle activity resulting from superposition — i.e. density — can be determined for any interval. Relative density for the major sixth (5:3) and major third (5:4) is computed in Diagram 10 (p. 189). The method is identical with that shown in Diagram 6.

We are now ready to evolve a complete scale of absolute sonority in terms of density ratings. The density of each of the intervals given in Table I (p. 191) was determined according to the method described above. Interval ratios are taken from the natural harmonic series.

Special mention should be made of the so-called "tritone" which derives its name from the fact that it contains three "whole-tones." This interval, proscribed in early polyphonic music as diabolus in musica (the devil in music), remains even today a ferment among the family of intervals due to its peculiar characteristics, the following being the most outstanding:

(1) the intervallic ratio for the tritone does not occur in the first sixteen partials of the harmonic series as do the other interval ratios. The proportions 5:7 or 7:10, contrary to popular opinion [14, 81-2], do not evoke the interval response we know as the "tritone effect." These proportions, when sounded in pure tone by oscillators, produce an effect which is unlike any interval among the first sixteen harmonics, but observers who have actually heard such an experiment[5] in the laboratory are aware that the aural response is not

5. Six trained musicians were tested (February, 1956) by the

TABLE I

DENSITY SCALE

Interval	Periodic Complexity Patterns from Wave Superposition
(1:1) Unison	1
(1:2) Octave	1 1
(2:3) P 5th	2 1 1 2
(3:4) P 4th	3 1 2 2 1 3
(3:5) M 6th	3 2 1 3 1 2 3
(4:5) M 3rd	4 1 3 2 2 3 1 4
(5:6) m 3rd	5 1 4 2 3 3 2 4 1 5
(5:8) m 6th	5 3 2 5 1 4 4 1 5 2 3 5
(5:9) m 7th	5 4 2 5 3 2 5 2 3 5 1 4 5
(9:10) M 2nd	9 1 8 2 7 3 6 4 5 5 4 6 3 7 2 8 1 9
(8:15) M 7th	8 7 1 8 6 2 8 5 3 8 4 4 8 3 5 8 2 6 8 1 7 8
(15:16) m 2nd	15 1 14 2 13 3 12 4 11 5 10 6 9 7 8 8 7 9 6 10 5 11 4 12 3 13 2 14 1 15
(70:99) Tritone	70 29 41 58 12 87 17 116 46 145 75 174 104 203 ... etc.

TABLE II

INTERVALS GROUPED ACCORDING TO DENSITY

Low Density (Group 1)	Medium Density (Group 2)	High Density (Group 3)	Special Case: Extremely High Density
Unison	M 6th	m 7th	Tritone
Octave	M 3rd	M 2nd	
P 5th	m 3rd	M 7th	
P 4th	m 6th	m 2nd	

that of the tritone. A true tritone of three whole-steps is achieved by dividing the octave in two equal parts — i.e. 600 cents or the ratio 70:99 [31, 7].

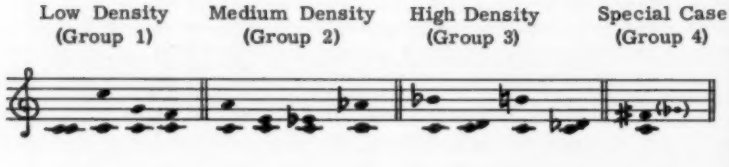
(2) it is the only interval without an inversion. When the frequency of its lower tone is doubled, the interval response remains exactly the same — e.g. 70:99=1.414; 99:140=1.414. The density scale illustrates the extreme complexity of the tritone; its symmetry accounts for its ambiguity.

(3) it is the only high-density interval essentially free of beating. Seconds and sevenths, in certain registers and at certain decibel levels, beat violently; but, as noted later, beating has nothing to do with the density phenomenon.

For the sake of convenience, the intervals may now be divided into four general classifications. These groupings are made on the basis of similarities between density patterns of the various intervals.[6]

The intervallic groupings in Table II may be notated musically as in Ex. 5. Similar (but incomplete) arrangements of interval values occur sporadically throughout acoustical literature (Helmholtz, Watson, etc.); but the reader is reminded that previous classifications of intervallic sonorities have been made mostly on a basis of "roughness" or "fusion" and, in contrast to the present method, have not actually produced visual evidence to show the reason for disposition of the intervals in a certain order. To say that an interval is "rough" does not show objectively how or why it is rough.

Example 5.



The theory that a graduation of interval values is dependent upon combination tones [14, 57-81] is even more questionable. Outstanding among the many weaknesses of this approach is the fact that combination tones vary with loudness levels [8, 292-6], as well as Steven's observation [27, 184] that difference and summation tones are produced only in the ear [see also 1, article "Combination Tones"].

writer in the Acoustics Laboratory of the Massachusetts Institute of Technology.

6. See pp. 198-200 of this article concerning the relation of intervals to their inversion.

THE PHYSICAL BASIS OF INTERVALLIC QUALITY

Beating — the interference phenomenon heard as minute intensifications of sound at regular periods — is an important factor in intervallic perception, being a characteristic feature of the high-density intervals in Group 3. It has also been noted, however, that beating is not an objective phenomenon but a subjective one[7]; "it is only because the two tones force into vibration two overlapping regions of the basilar membrane that an alternate waxing and waning of sound is heard" [27, 241]. Furthermore, the number of beats generated by an interval is not constant in different registers. There are only about 4 beats, for example, between c" and d♭", but between c"" and d♭"" there are about 16 [31, 12, 16]. Beating, whether of fundamental tones or harmonic partials, should not be confused with density.

Also, the distinction between the density concept and "small-number" theories of the past must be clearly understood. The latter held that tones whose frequencies were related as "small numbers" formed consonant intervals. This use of the word "consonant," as we have noted already, had no real significance in functional music, and to say that the ratio 1:2 produced a "smooth" interval did not show why or how such an interval might be rougher or smoother than another.

The concept of density not only provides visual description of relative complexity — regardless of register — but offers also a tangible scale of intervallic relationships which can be used to establish a mean rate of information exchange. The fact that all intervals besides the octave may be slightly mistuned and yet retain their essential identity does not detract from the potential usefulness of the density scale. Although the computation of intervallic complexity was necessarily worked out in terms of ideal interval ratios, slightly mistuned intervals will still retain the same relative degrees of complexity. The reader is reminded again of the ear's ability to discriminate the mean relationship between discrepancies in tuning and pitch ratios.

Caution should be exercised in applying the density concept to intervals exceeding the octave. The true nature of the octave phenomenon in music does not yet seem to be understood clearly. Révész has advanced the idea that the qualitative equivalence of tones an octave apart is due to their "phenomenological similarity" [24, 61] — i.e. there is "something" about tones separated by one or more octaves that makes them appear similar in quality, but not identical (contrary to popular belief). At any rate, the question has not been settled as to whether an eleventh, for example, is perceived as an intervallic unit (Gestalt) or as a perfect fourth by instantaneous octave adjustment. It is the writer's opinion that the latter states the case accurately since any interval, say a major seventh, can be made to sound like an octave duplication (on first impression) simply by sounding the two tones sufficiently far apart. An interesting experiment is related by Schillinger [26, 699] wherein trained musicians were unable to distinguish between short fragments of Grieg's Peer Gynt Suite played at the unison, and then at the seventh with a three-octave separation. In all probability

7. "Objective" and "subjective" are used advisedly here to differentiate between stimuli outside the skin as opposed to internal response. The density scale is a description of objective, physical phenomena in the time-domain.

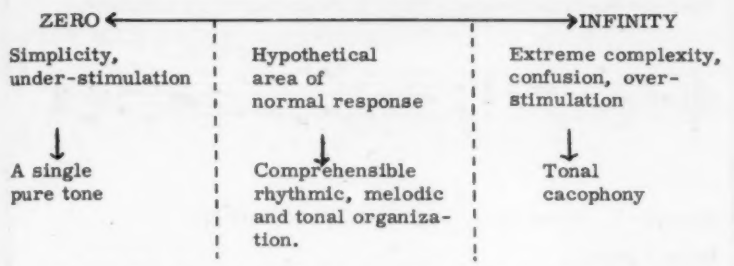
the ear judges intervals exceeding the octave in terms of its familiarity with intervals within the octave, and musical situations evaluated in terms of the latter will have essentially the same perceptual, if somewhat "distilled," effect. Therefore, density patterns within the octave are assumed to be adequate for the majority of musical problems.

The evaluation of intervals according to their stability-instability potential may now be achieved by means of density ratings, which provide a basis for the determination of simplicity-complexity patterns evolved from the juxtaposition of intervallic areas. The classification of static sonorities according to their relative complexity (density) provides a general approach to the understanding of consonant-dissonant relationships as found in Western music from c. 850 to the present. The density scale does not assort the intervals according to their consonance or dissonance, but offers criteria for the analysis and synthesis of functional intervallic relations according to context. Let us remember that consonance and dissonance in this study are regarded as functional combinations of tones which respectively stimulate responses of stability or instability.

An individual's reaction to observable phenomena, acoustical or otherwise, may be examined more readily with the help of a scale of measurement known as the Mean Rate of Information Exchange (RIE), which provides a general method for describing the relation between under-stimulation and over-stimulation. In music, for example, communication between the composer and listener might never be established if the latter received either too little or too much information from a particular composition. A highly complex piece of music might leave even the well-trained listener in a state of confusion and aesthetic frustration, and an absurdly simple composition might elicit from the same person either no response or, at best, expressions of boredom. Yet somewhere between these two extremes there lies an area of "knowledgeable evaluation" or "appreciation" wherein the trained listener experiences a normal rate of information exchange, and where he is able to perceive the composer's general intentions. This area of "normal" response is not unlike the point of balance which Heraclitus felt existed between the action of opposites.

Acoustically, a mean "sense of proportion" will be found somewhere between the under-stimulation of a single pure tone and the over-stimulation of tonal cacophony (e.g. successive, simultaneous blows of both forearms on the piano keyboard) which may be meaningless to the point of being described as "noise." Graphically, the mean RIE can be illustrated as follows:

RATE OF INFORMATION EXCHANGE SCALE

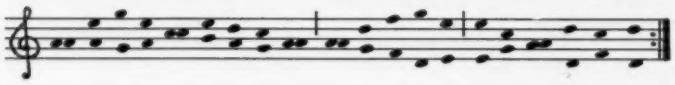


It is in the above-indicated "normal" area that, as Cazden puts it [7, ix], "the content of the music must be communicated somehow in its tangible sounding performance"; also it is with the aid of this terminology that music from various periods may be described objectively, without resorting to conflicting definitions. One might speak, for example, of a compositional style as being disturbing due to its extremely complex RIE or, perhaps, as being pleasing due to its balanced and relatively normal RIE. An objective method of controlling or evaluating the potential RIE of a given intervallic set is available through the use of the density scale. A too-rapid rate of information exchange might very correctly be described as dissonant, since the reference would be to a disturbing functional situation. Again, however, no interval in isolation should be called consonant or dissonant but, rather, should be referred to as having "low density," "medium density" or "high density" and therefore as being potentially stable or unstable.

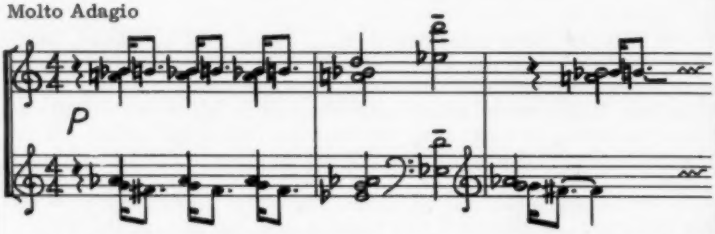
A contrapuntal situation involving low-density intervals from Group 1 is shown in Ex. 6 (p. 196). The RIE (rate of information exchange) in this example borders on under-stimulation due to the complete absence of medium- or high-density intervals which would tend to add elements of stress. Compare Ex. 6 with Ex. 7 which uses high-density intervals almost exclusively. The RIE in Ex. 7 borders on over-stimulation due to the almost complete absence of medium- and low-density intervals which would tend to add elements of repose. A mean balance between the above extremes can be obtained by using frequent medium-density intervals or by combining low, medium, and high as in Ex. 8. The RIE of Exx. 8a) and 8b) should be within the area of normal response due to the balanced use of low- and medium-density intervals, in combination with a smaller number of high-density intervals.

Scoring, dynamics, and various coloristic devices can be used to obscure the simplicity-complexity relations of intervallic areas, but the density scale furnishes a generally concrete approach to the analysis of consonant-dissonant situations. Note how the consonant (balanced) effect of Ex. 9 (p. 197) is abruptly disturbed by the sudden and unwarranted insertion of a high-density interval in m. 5, thus producing a dissonant (unbalanced) response at that point. Yet, the same chord-structure fails to evoke a dissonant response if it occurs in a different

Example 6. Cunctipotens genitor (11th-century free organum).



Example 7. Minor 2nds, Major 7ths (Bela Bartók).

Molto Adagio

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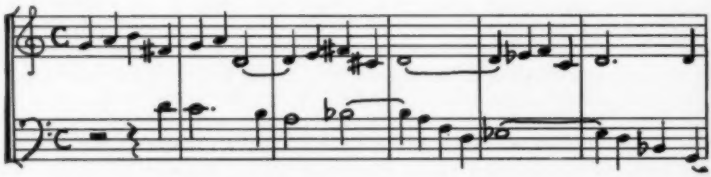
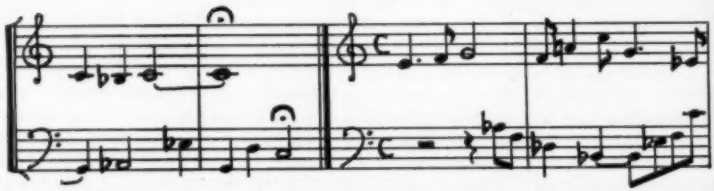
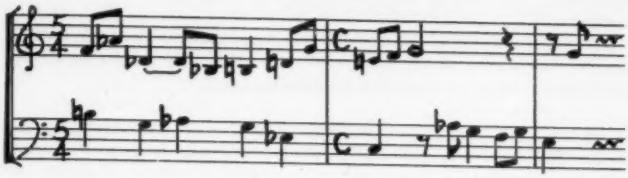
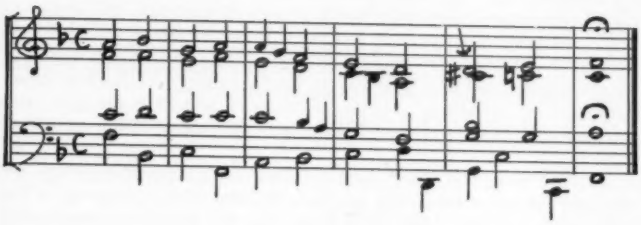
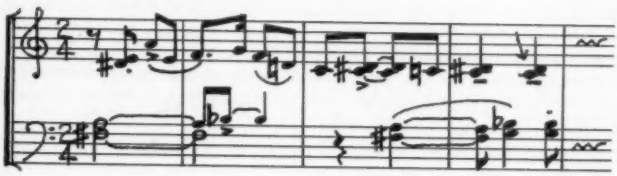
Example 8.

a)

b)



Example 9.

Slowly

Example 10.

Moderately

setting (Ex. 10).

No interval, therefore, can be termed consonant or dissonant without consideration of context; but this does not eliminate the classification of isolated intervals, since now we can evaluate them in terms of their relative density and actually visualize their probable tendency toward under-stimulation or over-stimulation.

The similar quality of inverted intervals is also explained by the density scale. The perfect fifth (2:3), when inverted, becomes a perfect fourth (3:4), but what is there about the density rating of these intervals that explains their similarity in quality?

An interval is said to be inverted when the frequency of its lower tone is doubled, or when the frequency of its upper tone is halved. Inversion is also the process of reversing the relationship between two tones so that the common product (C.P.) of their frequencies is doubled (or vice versa). The common product of the ratios forming a major third (4:5), for example, equals 20. The product of the ratios forming its inversion, the minor sixth (5:8), equals 40. Also, the various density patterns which result from the wave superposition might be expected to display multiple relationships when an interval is compared with its inversion, i.e. the density rating of an interval should be doubled (or halved) when the interval is inverted. This is exactly the case, since the density pattern of a perfect fifth (2112, totaling 6 fluctuations), doubles itself when inverted to a perfect fourth (312213, totaling 12 fluctuations). Furthermore, that position of an interval whose ratio yields the largest common product manifests a density pattern which is directly related to the density pattern of its inversion. This relationship is expressed by means of duplicate numbers and also integers resulting from the summation of terms in that inversion with the smallest C. P.

Assume, for example, that the two intervals in question were the perfect fifth and its inversion, the perfect fourth. By referring to the density scale in Table I (p. 191), it is seen that the periodic complexity pattern of the fifth is 2112; of the fourth, 312213. The frequency ratio of the latter is 3:4 (C. P. = 12); that of the former, 2:3 (C. P. = 6). The fourth, therefore, having the largest common product, contains integers in its density pattern (Ex. 11, p. 199) which result from a summation of terms (in brackets) in the density pattern of the fifth. The same holds true for all other intervals and their inversions. Ex. 12 illustrates the numerical relationship between the major third and minor sixth. Note that numbers in the periodic pattern of the minor sixth are either duplicates or the result of summed terms from the major third's density pattern.

The significance of this seemingly abstract analogy should not be overlooked by the reader. Remember that the various numbers in all the density patterns represent the time which elapses between moments in wave superposition when there is no reinforcement or cancellation of amplitude. When an interval is inverted these moments remain essentially the same, with the exception that some of the terms combine to form larger integers in the inverted interval. It is not surprising, therefore, that a similar quality exists between an interval and its inversion. The writer submits that this similarity in quality is largely

Example 11.

Perfect 5th (C. P. 6) 2112 / 2112 / 2112 / 2112

Perfect 4th (C. P. 12) 3 12 / 21 3 / 3 12 / 21 3

Example 12.

Major 3rd (C. P. 20) 41322314 / 41322314

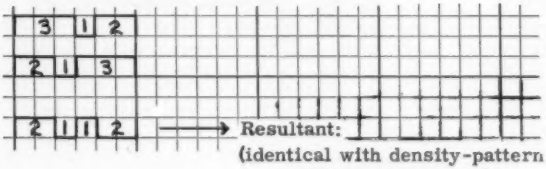
Minor 6th (C. P. 40) 5 32 514 / 41 523 5

Diagram 11.

Perfect 4th (3:4) 3 1 2 | 2 1 3

Axis of Symmetry*

Displaced in simultaneity:

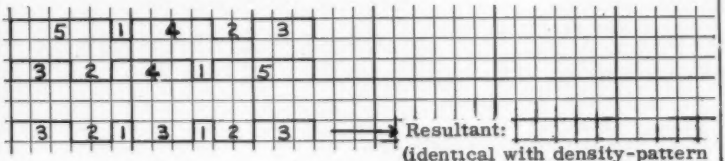


(identical with density-pattern of the perfect fifth)

Minor 3d (5:6) 5 1 4 2 3 | 3 2 4 1 5

Axis of Symmetry*

Displaced in simultaneity:



(identical with density-pattern of the major 6th)

*That point after which the number pattern repeats itself in reverse order.

due to coincident events in the time-domain, and that these events may be described in terms of numerical relationships between density patterns of the intervals.

The inextricable bond of periodic complexity between an interval and its inversion is further evidenced by displacing the density pattern of any interval in simultaneity from its axis of symmetry (start with that position whose ratio yields the largest common product). The resulting periodicity corresponds identically to the inversion of that interval (Diagram 11).

The potential tendency towards stability of all types of chord-structures may be evaluated by means of the density scale. The reader is reminded again, however, that the roughness caused by beating has nothing to do with the density theory per se. The diminished-7th chord, for example, contains no intervals that "beat," but still has a pronounced forward tendency to move to another harmony due to the presence of two high-density tritones. The relative stability of all intervallic sonorities is based on the following principle: structures with the highest density rating will have the strongest tendency toward instability.

In Table II (p. 191) the various intervals were classified as low density (unison, octave, fourth, fifth), medium density (thirds, sixths), high density (seconds, sevenths), and the tritone as a special case. These four groupings are used as a convenient basis for the computation of relative stability:

(1) Group 1 intervals are given a rating of 1;
(2) Group 2 intervals are given a rating of 2;
(3) Group 3 intervals are given a rating of 3;
(4) The special-case tritone is given a rating of 4.

The density ratings of various structures may be obtained easily by using the above classification. Among the 3-part (3p) structures, for example, the four common types of triads[8] would be rated as follows:

S5 maj: contains 1 interval from Group 1 and 2 from Group 2.
Density rating = 5

S5 min: contains 1 interval from Group 1 and 2 from Group 2.
Density rating = 5

S5 aug: contains 3 intervals from Group 2.
Density rating = 6

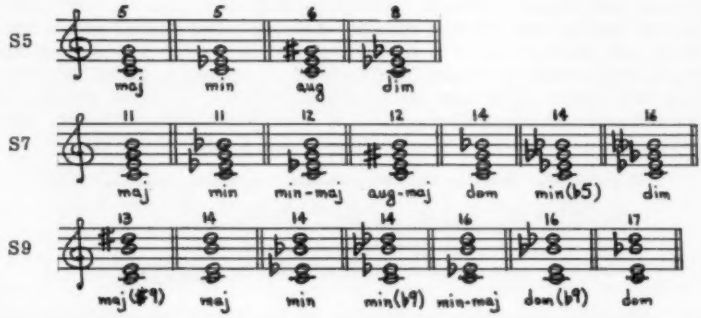
S5 dim: contains 2 intervals from Group 2 and one from Group 4.
Density rating = 8

8. As suggested by Schillinger [26, Book V], S5 (S = structure) denotes a triad built in thirds; S7, a 7th chord built in thirds; S9, a 9th chord built in thirds.

TABLE III

DENSITY ANALYSIS OF STANDARD CHORDS

Chord Structure		Number of Intervals in Each Group				Total Density
		1	2	3	4	
S5	maj	1	2	0	0	5
	min	1	2	0	0	5
	aug	0	3	0	0	6
	dim	0	2	0	1	8
S7	maj	2	3	1	0	11
	min	2	3	1	0	11
	min-maj	1	4	1	0	12
	aug-maj	1	4	1	0	12
	dom	1	3	1	1	14
	min (♭5)	1	3	1	1	14
	dim	0	4	0	2	16
S9	maj (♯9)	1	3	2	0	13
	maj	1	2	3	0	14
	min	1	2	3	0	14
	min (♭9)	1	2	3	0	14
	min-maj	0	3	3	0	15
	dom (♭9)	0	3	2	1	16
	dom	0	2	3	1	17


S5
5 5 6 8
maj min aug dim
S7
11 11 12 12 14 14 16
maj min min-maj aug-maj dom min(♭5) dim
S9
13 14 14 14 16 16 17
maj(♯9) maj min min(♭9) min-maj dom(♭9) dom

Observe that these ratings correspond to the traditional treatment of the above triads — i.e. the augmented triad is considered less stable than the major or minor, and the diminished triad is the least stable of all due to its high density rating. Ratings for the 7th chords (S7) and 9th chords (S9) are derived in the same way. Table III (p. 201) shows comparative density ratings for triads, 7ths and 9ths. To avoid confusion in terminology, these structures are shown below Table III in musical notation. The number above each chord is its density rating.

The same principle applies to progressions of less common structures. The isolated chords in Ex. 13 (p. 203) can be arranged so as to express increasing instability (approach to climax) or increasing stability (approach to cadence, or point of rest) simply by distributing them in accordance with their increasing or decreasing density. Increase in forward tendency (instability) indicated by ▬▬▬▬; decrease in forward tendency (stability), ▬▬▬▬; no change (neutral), ▬▬▬▬.

Two chords with the same apparent density rating — e.g. the second and third chords in Ex. 13b) — may still be evaluated comparatively by examining each structure more closely. Note that the second chord in Ex. 13b) contains two intervals from Group 1, three intervals from Group 2, and only one from Group 3, whereas the third chord contains two intervals from Group 3. Since the latter chord has more Group 3 intervals than the former, it is considered to be less stable, even though the overall density rating for both structures is the same. The general rule for comparing chords with the same rating is as follows: When two or more structures have the same density rating, that structure containing the most intervals from the group with the highest density rating will have the strongest tendency towards instability.

In Ex. 14 (p. 203) there are several chords with the same rating. It is still possible, however, to evaluate the relative stability of these structures by determining which chords have the most intervals in groups with higher ratings. Note that chord E in Ex. 14, not containing the tritone, has greater stability than the other chords with a rating of 14; and although chord D contains a tritone, it does not have as many Group 3 intervals as B and C. There is no change in stability between chords G and H since both these structures have the same kinds of intervals from the same Groups — i.e. each has a perfect fourth, major sixth, two major thirds, a minor sixth, and a minor second.

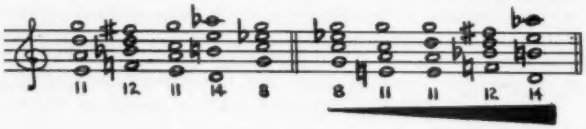
In general, chord progressions are normally controlled by:

(a) stability-instability of vertical structures;
(b) linear motion of individual parts;
(c) any combination of (a) and (b).

Stability-instability tendencies of the above progressions were controlled by redistribution according to density ratings, but activity in progressions such as the following results from linear part movement towards cadence points, not from structure. Note the predominately "neutral" effect of the harmony in Ex. 15 all structures of which have the same density rating — i.e. 5 (each chord contains one Group 1 interval and two Group 2 intervals).

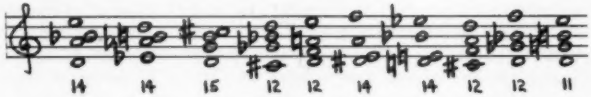
Example 13.

a) Original progression. b) Redistribution to express increasing instability.

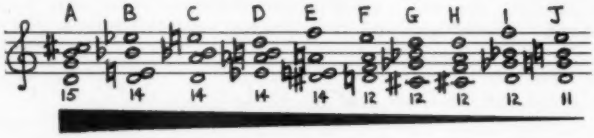


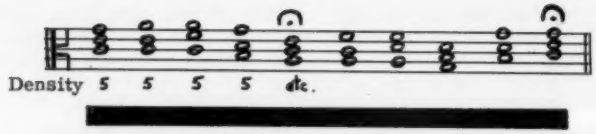
Example 14.

a) Original progression.



b) Redistribution to express increasing stability (cadence).



Example 15.

Pressure changes resulting from molecular compression variations are brought about by the tremulous motion of material objects, which causes a displacement of air particles. This action results in an alternation of particle condensation and rarefaction constituting the phenomenon known as vibration, and the hearing response to vibratory motion is termed sound. Regular air vibrations with a speed of around 16 to 40 times per second and faster may be perceived as pitch; the sensation of interval is produced by combining two or more pitches. The amplitude-periodicity relationships (in the time-domain) between two tones may be established by examining the points in time where no reinforcement or cancellation exists between wave trains, and between which points all pressure fluctuations take place that produce patterns of change in particle activity. These patterns, reflecting the intensity of molecular activity in a perceivable intervallic area, provide the means for measuring the relative density of such an area, thus paving the way for a scale of absolute intervallic sonority.

The density scale, which does not vary appreciably with register or intensity (as do beats and combination tones), offers visual evidence of the probable tendency of the intervals towards stability or instability. The medium-density thirds and sixths of Group 2, serving as a convenient mean between extremes, have provided a relatively stable foundation for most of the music in Western civilization (especially since c. 1450). The unprecedented popularity of these intervals is evidenced by many rules of traditional theory, one of the more interesting of which is the principle that thirds and sixths are the only intervals permitted to move in parallel motion in strict counterpoint [12, 20]. Parallel motion between the low-density octave and fifth, or the high-density seconds, sevenths and tritone, is strictly forbidden [12]; but the "middle ground," less sharply defined thirds and sixths have received the blessings of pedagogues for many years. They have been, in fact, the "normal expression of consonant moments in the musical system of the tonal era" [7, 297].

The answer to Aristotle's query, "Why is it that the difference of an octave may be undetected and appear to be unison?" [2, 385] is relatively simple when viewed in terms of density ratings. The octave is the only interval besides the unison whose periodic complexity pattern contains no integers other than the number "1" (i.e. complete uniformity) and, by comparing the density of the two intervals, it is seen that the pattern for the octave is nothing more than a duplication of that of the unison.

The high density intervals of Groups 3 and 4, on the other ex-

treme, manifest a complexity that warrants careful handling. Even today, an intervallic framework which fails to use these intervals judiciously is in danger of stimulating a response which lies beyond the normal area of information exchange — i.e. to many listeners, the musical situation tends to be too complex for aural comprehension — witness, for example, many works of the "atonal" school, such as Schonberg's Suite, Op. 25, Berg's Lyric Suite, Krenek's Karl V, etc.

In addition to explaining the similar quality of inversions and helping to establish criteria for a normal RIE, the density scale is especially valuable for judging the relative stability of chord-structures. Although any chord can be made to sound consonant (stable) or dissonant (unstable) by adjusting the musical context, it is still extremely important to realize that some structures have a more pronounced tendency towards instability than others.

The density scale serves as a source of criteria for establishing group-ratings for the various intervals. These ratings provide an objective method for the evaluation and control of stability-instability patterns, and eliminate the necessity for using conflicting pseudo-definitions. The expressions "consonant" and "dissonant" may now be reserved for strictly functional situations where, in the writer's opinion, they properly apply; and isolated intervals can be described as low-density intervals, medium-density intervals, and high-density intervals.

The latter classifications offer the theorist and music educator objective, relatively concise language for the analysis and synthesis of widely divergent musical styles. It should be necessary no longer to teach beginning students that one set of intervals must be categorized as "consonances" and another as "dissonances," only to ignore these classifications in musical practice. In view of the impracticality of the continued use of these words to describe both the functional (musical) and non-functional (laboratory), it seems advisable to employ terminology which avoids the connotative contradictions of the past. The need for new language is acute. Perhaps the density scale can meet this need.

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THE HARMONIC TENDENCY OF THE HEXACHORD

by

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Since 1908, when Schoenberg dispensed with chords founded on the principle of root, third and fifth, harmony based on the "emancipation of the dissonance" has flourished but in what seems to have been a largely arbitrary manner. The chords to be found in the atonal works and, later, in the 12-tone works of Schoenberg, Webern, and Berg do not lend themselves to a handy system of classification by formal function (as in historical tonality) or numerical description (as in figured bass). The belief has grown over 50 years that no demonstrable basis for these chords exists, that they have no perceptible logic or grammar. In the case of 12-tone music, chords are generally justified by their derivation from the row. If chords thus derived happen to have the structure of triads, then historical tonality is brought in to justify their presence and due emphasis is placed on the unlimited artistic freedom allowed in 12-tone composition. The willingness to continue these irrelevancies seems to exist on all sides and is beautifully illustrated by this quote from a recent writing of Walter Piston [9, 47].

> In serial writing, besides the harmonies created by combined contrapuntal voices, chords are made by presenting fragments of the series as vertical instead of horizontal sonorities, a procedure not unknown to conventional tonal music. These harmonic sounds may be accepted by the composer as they happen to come in numerical order, or they may be rearranged in spacing and inversion according to the composer's wishes. On the other hand, the composer may manipulate the series so that notes become available to create harmonies decided upon in advance... It goes without saying that ordinarily the chords are not chosen for their tonal relationships, but for qualities such as tension, relaxation, colour, dynamic effect, and so forth.

While Piston does not say there is anything arbitrary about all this, it is very hard to avoid this interpretation of the description he offers, especially in view of his choice of language: "made by presenting fragments," "as they happen to come," "may manipulate," etc. Piston goes on to say:

> These various aspects are to be considered when appraising harmonic procedures in serial technique. It is clear that the principles involved afford virtually endless freedom. In the light of this freedom it is at least permissible to view the tonal aspects of Berg's "Violin Concerto" as something more than a hangover from an outmoded style or nullification of serial principles.

What criteria other than the "aspects" he refers to exist for "appraising harmonic procedures in serial technique" Piston does not say. We know no more about 12-tone harmony after reading Piston than we knew before. In the final analysis his point of view simply corroborates the generally held assumptions that the sky is the limit in 12-tone harmony and that anything goes. The inadequacy of this view is further illustrated by statements made by Hans Nathan [7, 290]: "Moreover, if the harmony is built up by means of serial verticalization (and this is the only case where it has any measure of predictability), countless sonorities can be brought about through a change in the order of the tones (to say nothing of an inconsistent downward or upward alignment), through segmentation and spacing, sustained and repeated tones." What, after all, does this say about 12-tone harmony?

The evidence, as it turns out, proves this view ill-founded. Far from being arbitrary or fanciful, 12-tone harmony begins to reveal itself as a new language of chords with its own inherent laws of structure, the chief one being that of symmetry. It is not my purpose to pursue this in a broad, general sense but rather to lead my discussion to a particular case in Schoenberg's music where the principle of symmetry functions in harmonic practice to a maximum degree. In order to do this it will be necessary to prepare the ground with a full investigation of the hexachord. It is from the inherent symmetrical order of the mirroring hexachord that this harmonic tendency arises and establishes the possibility of a new type of vertical order in 12-tone music.

To avoid confusion in terminology, we must agree that basic set, series and row (or tone-row) are interchangeable terms which refer to an order of the 12 pitches in an octave arranged by a composer for compositional use. Milton Babbitt's term, source-set, is another matter entirely. This term implies a general type existing prior to any compositional situation from which may be derived particular pitch orders of the 12 semitones preparatory to composition. Joseph Hauer's tropes, on the other hand, are not to be considered basic sets, series, rows or source-sets in the sense described above because they comprise a pre-determined system which is self-enclosed and ready-made for composition. Hauer apparently placed no restrictions on the number of different tropes which can be used in a given work, an idea directly opposite to the method of 12-tone composition practiced by Schoenberg and Webern.

Unfortunately, Babbitt's complete theory of set-structure and "combinatoriality" is not yet available in published form. However, some years back he made reference to it in an article [5] on the state of 12-tone music in the United States. The outline he offers there suggests that, so far as the general theory of set-structure is concerned, there is little more to be done in this direction. In my monograph [2] on the hexachord I stated laws of row-construction, in terms other than Babbitt's, which apparently form only a part of the theory of set-structure. In order to examine further the ramifications of the hexachord, and particularly certain harmonic consequences, I must risk stating again in my own terms what I surmise are aspects of Babbitt's theory. I shall try to point out, in so far as they can be distinguished, which are Babbitt's ideas and which are my own. In combination with

TABLE I

THE HAUER TROPES*

1.	1	2	3	4	5	6	7	8	9	10	11	12
2.	1	2	3	4	5	7	6	8	9	10	11	12
3.	1	2	3	4	6	7	5	8	9	10	11	12
4.	1	2	3	5	6	7	4	8	9	10	11	12
5.	1	2	4	5	6	7	3	8	9	10	11	12
6.	1	2	3	4	7	8	5	6	9	10	11	12
7.	1	2	3	6	7	8	4	5	9	10	11	12
8.	1	2	3	7	8	9	4	5	6	10	11	12
9.	1	2	3	4	6	8	5	7	9	10	11	12
10.	1	2	3	5	7	8	4	6	9	10	11	12
11.	1	2	4	5	7	8	3	6	9	10	11	12
12.	1	3	4	5	7	8	2	6	9	10	11	12
13.	1	2	4	6	7	8	3	5	9	10	11	12
14.	1	3	4	6	7	8	2	5	9	10	11	12
15.	1	2	3	5	6	8	4	7	9	10	11	12
16.	1	2	4	5	6	8	3	7	9	10	11	12
17.	1	3	4	5	6	8	2	7	9	10	11	12
18.	1	2	3	5	6	9	4	7	8	10	11	12
19.	1	2	4	5	6	9	3	7	8	10	11	12
20.	1	2	3	6	7	9	4	5	8	10	11	12
21.	1	2	5	6	7	9	3	4	8	10	11	12
22.	1	2	3	5	8	9	4	6	7	10	11	12
23.	1	2	3	6	8	9	4	5	7	10	11	12
24.	1	4	5	6	8	9	2	3	7	10	11	12
25.	1	2	4	5	8	9	3	6	7	10	11	12
26.	1	2	5	6	8	9	3	4	7	10	11	12
27.	1	2	4	5	7	9	3	6	8	10	11	12
28.	1	2	4	5	7	11	3	6	8	9	10	12
29.	1	2	4	5	9	11	3	6	7	8	10	12
30.	1	2	4	5	7	10	3	6	8	9	11	12
31.	1	2	4	5	8	10	3	6	7	9	11	12
32.	1	2	5	6	8	10	3	4	7	9	11	12
33.	1	2	5	6	8	11	3	4	7	9	10	12
34.	1	2	5	6	9	10	3	4	7	8	11	12
35.	1	2	4	6	7	9	3	5	8	10	11	12
36.	1	2	6	7	9	11	3	4	5	8	10	12
37.	1	2	4	6	7	11	3	5	8	9	10	12
38.	1	2	4	7	8	10	3	5	6	9	11	12
39.	1	2	3	5	7	9	4	6	8	10	11	12
40.	1	2	3	5	7	11	4	6	8	9	10	12
41.	1	3	5	6	8	10	2	4	7	9	11	12
42.	1	2	4	6	8	10	3	5	7	9	11	12
43.	1	3	4	6	8	10	2	5	7	9	11	12
44.	1	3	5	7	9	11	2	4	6	8	10	12

*Contained in Karl Eschmann's Changing Forms in Modern Music, E. C. Schirmer Music Co., Boston. Copyright 1945 by E. C. Schirmer Music Co. Used by permission.

these ideas I will also draw on Joseph Hauer's formulation of tropes.

First, I will discuss the tropes of Hauer to show how they relate to the principles of hexachordal row-construction. While I would prefer to present the tropes of Hauer in notation, space limitations require the use of numbers instead (see Table I, p. 210). The digits from 1 to 12 are assigned to the successive pitches of an ascending chromatic scale from C-natural. C-natural is represented by 1; the B-natural a seventh above, by 12.[1] Series of all twelve numbers are then constructed so that six numbers in ascending order are separated from and followed by the remaining six, also in ascending order. These numbers represent ascending pitch-orders. Provided that pitches 1 and 12 retain their respective positions at the beginning of the first hexachord and the end of the second hexachord, 44 such arrangements are possible. By making use of the devices of transposition and permutation within each hexachord, any 12-tone row can be demonstrated to derive from one or another of these 44 tropes.

It would be worthwhile to undertake a specific analysis of each trope, testing for hexachords which produce their complementary non-duplicating groups of six tones by symmetrical inversion. All we can do here is to show the actual results of this analysis, results which demonstrate that, while Schoenberg and Hauer differed in the applications of their respective 12-tone methods, their methods ultimately rested on semitone orders which are reducible to a single system. This in turn leads us to the not too surprising conclusion that Babbitt's source-sets are a theoretical formulation analogous to the results of our analysis and that both, in fact, are the same principle seen from different vantage points.

There are five classes of tropes:

1. Those which invert mirror-fashion singly (or at only one point of inversion or level of transposition) without producing duplication of notes[2] in paired antecedent and consequent hexachord-mirror combinations: 1, 2, 6, 9, 17, 18, 21, 23, 30, 32, 39, 40, 41, 42, 43.

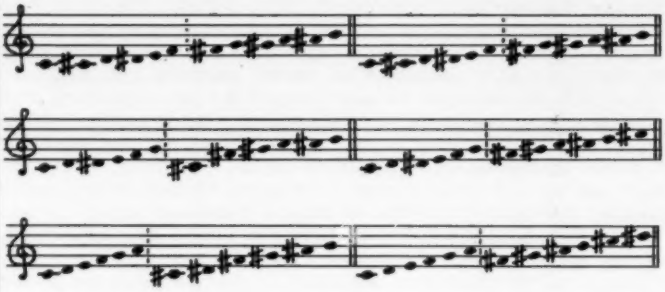
2. Those which invert mirror-fashion doubly (or at two different points of inversion or levels of transposition) without producing duplication of notes in paired antecedent and consequent hexachord-mirror combinations: 8 and 38.

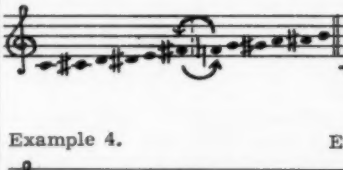
3. The one which inverts mirror-fashion triply (or at three different points of inversion or levels of transposition) without producing

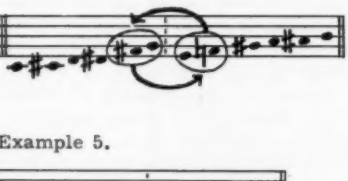
1. The reader who is familiar with my monograph [2] will remember that there I designated the first note of a series as zero (0). This was necessary in order to arrive at precise numerical designations in semitones for interval distances from the first note: thus C was 0; C#, 1; D, 2; etc. Note also that there is a difference between merely stating a position of order in a series of 12 semitones (as in the Hauer tropes) and stating interval distances from an initial reference point.

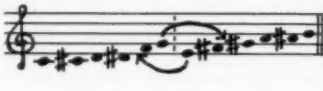
2. The term, "duplication of notes," is preferable to "octave doubling." The latter calls to mind tonal practice in part-writing and voice-leading; the former does not call up this association which is irrelevant in hexachordal problems.

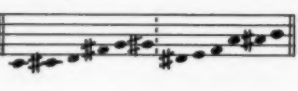
Example 1.

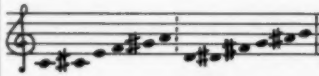
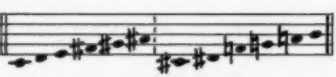
Hauer Tropes Source-Sets

Example 2.



Example 3.

Example 4.



Example 5.

Example 6.

Example 7.

Example 8.

duplication of notes in paired antecedents and consequent hexachord-mirror combinations: 34.

4. The one which inverts mirror-fashion sextuply (or at six different points of inversion or levels of transposition) without producing duplication of notes in paired antecedent and consequent hexachord-mirror combinations: 44.

5. Those which do not invert mirror-fashion without producing duplication of notes in paired antecedent and consequent pseudo-hexachord-mirror combinations because their internal structures lack the required symmetrical characteristics, thus placing them outside the range of laws which affect hexachordal construction: 3, 4, 5, 7, 10, 11, 12, 13, 14, 15, 16, 19, 20, 22, 24, 25, 26, 27, 28, 29, 31, 33, 35, 36, 37.

The next important step is to establish the connection between the above trope classes and the four orders of source-sets which Babbitt designates:

First order: Three source-sets which produce, mirror-fashion, a single inversion without producing duplications of notes in paired antecedent and consequent hexachord-mirror combinations. These sets are either identical with or analogous to Tropes 1, 17 and 41 (Ex. 1, p. 212).

Trope 17 is analogous to Source-Set 2, not identical with it. Babbitt places the C# at the end of Set 2 so that the form of the second hexachord is an exact retrograde inversion of the first hexachord of his set. Hauer places the C# at the head of his second hexachord in order to retain the final B which is the outer limit of all his tropes. This explains why we find C#-D# as the last two notes of Source-Set 3 and as the first two notes of the second hexachord of Trope 41.

By a process of exchanging notes we see that Trope 2 can be reduced to Source-Set 1 (Ex. 2) and therefore be said to derive from it; in similar fashion, Tropes 6 (Ex. 3) and 9 (Ex. 4).

Second order: One source-set (4) which produces, mirror-fashion, inversions at two different points of inversion or levels of transposition without producing duplication of notes in paired antecedent and consequent hexachord-mirror combinations. This set is identical with Trope 8 (Ex. 5). Trope 38 also produces two inversions under the same conditions as Trope 8. By an exchange of notes it may be reduced to Source-Set 4 (Ex. 6).

Third order: One source-set (5) which produces, mirror-fashion, inversions at three different points of inversion or levels of transposition without producing duplication of notes in paired antecedent and consequent hexachord-mirror combinations. This set is identical with Trope 34 (Ex. 7).

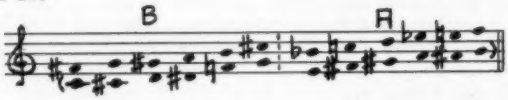
Fourth order: One source-set (6) which produces, mirror-fashion, inversions at six different points of inversion or levels of transposition without producing duplication of notes in paired antecedent and consequent hexachord-mirror combinations. This set is identical with Trope 44 (Ex. 8).

This is as far as it is necessary to go in establishing a clear-cut connection between Hauer's tropes and Babbitt's source-sets. In effect, the latter establish the theoretical ground for those classes of the former which are organized by symmetrically inverting hexachords. It is this type of hexachordal symmetry which we know to be basic to Schoenberg's construction of tone-rows and without which we cannot fully understand the extent of his technical achievement.

Before passing on to discuss the trope classes or order of source-sets to which typical Schoenbergian rows belong, I wish to pose this hypothesis as a ground for doing so: Any 12-tone row, whether based on the principle of symmetrical hexachordal construction or not, can be reduced to one of the 44 tropes of Hauer; and, if based solely on this principle, by analogy, to one of the source-sets of Babbitt. In his book, Eschmann remarks [1, 86], "It is true that any 12-note melody can be found in one of the 44 tropes..." Later he says [1, 104]: "It appears at first glance that Schoenberg's 'series' bear some resemblance to Hauer's 'tropes'... However, the distinctions are so important that we may consider Schoenberg's 'series' as a different method, attempting to solve the same problem." However, the resemblance between the two, series and tropes, goes deeper than the word "resemblance" itself implies; the series are forms directly traceable to tropes while the tropes find their theoretical analogue in Babbitt's formulation. Therefore, whether we are considering a row of Schoenberg, a trope of Hauer, or a source-set of Babbitt, we are dealing with phenomena which reduce ultimately to a fundamental unity.

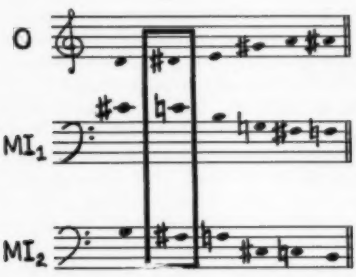
Example 9.

Example 10.



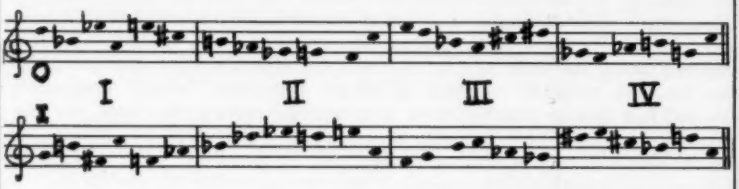
Let me demonstrate briefly how we may trace a Schoenberg row to a Hauer trope and then relate it to a source-set of Babbitt. By reducing the row of the Piano Concerto, Op. 42 to its scalar form, we achieve the result shown in Ex. 9 (above). The notes of the row are arranged conjunctly, retaining their original hexachordal division. If we exchange hexachords we find that we have a transposed version of Trope 9 (Ex. 10). Trope 9, as we discovered before, derives from Babbitt's first order, Source-Set 1. This procedure may be followed for any row and it will be found that without exception any row can be traced to a trope-form and trope-class.

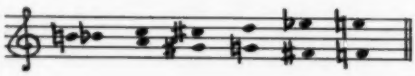
Utilizing this technique, it would be easy enough to establish the classification of each row Schoenberg devised. In lieu of a complete analysis, a few remarks pertinent to this discussion must suffice. Schoenberg, at one time or another, made use of each trope-class (or set-order). For example, the row of Op. 30 is non-hexachordal (therefore non-inverting without duplication of notes), one of the very few, another being the row of Op. 48, No. 1. Most of his rows are hexachordal, the majority of them inverting only once. While Schoenberg himself has told us that he liked to invert his rows at the fifth, we discover rows which invert singly at the minor third (Op. 23, No. 5), or fourth (Op. 25),[3] or minor second (Op. 26). In these early 12-tone works it is worth noting that Schoenberg makes no use of the mirror in Op. 23, No. 5; that in Op. 25, he inverts his row at the tritone instead of the fourth (see his own discussion of this row [4, 127-9]); and that he uses octave and fifth inversions of the row of Op. 26 instead of its hexachordal point of inversion at the minor second [4, 118]. What is most surprising of all is that, as early as Op. 29, Schoenberg used a row which inverts at three levels, the minor third, the fifth, and the major seventh, although he made use of the one at the fifth only. The identical situation occurs in Op. 41. But when he planned Op. 50c, whose row derives from the same class as Op. 29 and Op. 41, he intended full use of the three inversions as evidenced by the series plan.[4] Another unusual case is Op. 48, No. 3, composed in 1933, where the only inversion used of the six possibilities is the one at the fifth. This is a whole-tone row, based on Trope 44 (Source-Set 6). A study of the work clearly reveals the whole-tone nature inherent in the row.

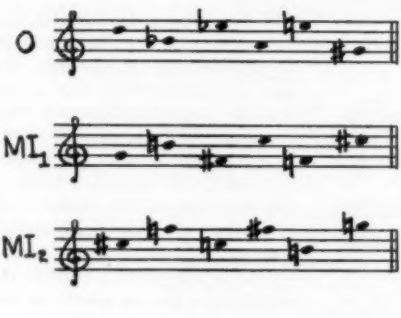
Example 11.

Of special interest is the hexachord of Op. 50b, the De Profundis for 6 voices, the last of Schoenberg's completed works; I say "hexachord" because there is no row as such. The total 12 notes are present, however, in combinations of the hexachord and either one of its two mirror-inversions. Analysis shows that the hexachord is based on Trope 8, its inversions taking place at the minor second and fifth below its initial note (Ex. 11). To show this I have bracketed the initial note of Schoenberg's hexachord and its points of inversion. It is interesting to note that, whereas in doubly inverting hexachords or hexachordal rows the interval-distance between inversions is always a tritone, in triply inverting hexachords or hexachordal rows the in-

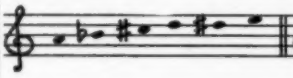
3. See Richard Hill's review of the author's monograph [2] in MLA NOTES, March, 1955, pp. 224-5. There, Hill correctly points out that the row of Op. 25 is hexachordal. In my monograph, I erroneously offered this same row as non-inverting.

4. See Rufer [3, opposite 11] for a facsimile of this plan.

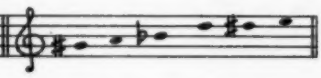
Example 12.

Example 13.



Example 14.

Example 15.



Example 16.



terval-distance between inversions is always a major third.

Let us sum up our findings. By testing the 44 tropes of Hauer we discovered five classes, the first four of which are analogous to Babbitt's set-orders and source-sets. We were able to show that, while the former were established for compositional use, the latter were theoretical formulations supporting and paralleling them in large measure. We were then able to point out the means by which any row can be shown to derive from one of the 44 tropes and, provided it was symmetrically organized by hexachords, that such a row can be directly related to one of Babbitt's source-sets.

One of the significant results of our discussion so far is to have established the fact that, in addition to single inverting hexachordal rows, there are rows which invert at two, three and six levels; that Schoenberg knew this; and that, toward the end of his life, he consciously began to employ row formations which produce such multiple inversions. Even though he used rows with triple inversion possibilities (Op. 29 and Op. 41), he did not consciously plan to use these possibilities until Op. 50c. Nor did he use the sextuply inverting row (which, paradoxically, leads back to the whole-tone music of Debussy) except in Op. 48, No. 3. This work (and the trope and source-set on which it is theoretically based) affords us the opportunity to remark that 12-tone row-construction points the way to the inclusion in 12-tone composition of the historically exhausted and short-lived practice of whole-tone music.[5] That this indicates the far-reaching consequences of a developing theory of 12-tone music, a theory whose outlines we begin dimly to perceive, becomes self-evident.[6]

The recognition of the hexachord as a unit of 12-tone construction made possible a greater flexibility in composition since, as a unit, its individual members were no longer forced into an immutable order. If the law of invertibility of hexachords created an indissoluble relationship between the interval partners of original and mirror, then, no matter where a note was shifted within its hexachordal unit, it must inevitably carry with it its mirror partner. Robert Gerhard points out [6, 33] that Schoenberg is not taking liberties with the note order when he shifts notes around in the constituent hexachords of Von Heute auf Morgen, Op. 32: "What he is doing is something quite different. Our example goes to show that he treats either of the two halves of the series as interchangeable with its corresponding hexachord—which postulates a relation of identity between the two interchangeable units." Gerhard likens this to Rameau's identity of the triad and its inversions which remain the same chord under different aspects. Gerhard maintains [6, 33] that "the acceptance of the principle of permutation (within

5. See Perle [8, 300-1] where he discusses the symmetrical nature of the whole-tone scale.

6. I should like also to direct attention to the diatonic characteristics of Trope 41 (Source-Set 3) which suggests that there may be some meaningful, organic connection between pre-classical music, based to a large degree on the diatonic hexachord "ut-re-mi-fa-sol-la," and the total chromaticism of 12-tone music.

antecedent and consequent)" is necessarily "based on a recognition of the fact that beyond the actual series there is an ultimate gound, an abstract archetype — represented by the coupled hexachords — of which the individual series is only one aspect, that is, of the possible permutations." This "ultimate gound" to which Gerhard refers is, as we now know, the law of invertibility which links interval partners in an indissoluble bond and governs their mutual actions in "coupled hexachords."

Permutation of notes within hexachords is precisely the device which characterizes Schoenberg's String Trio, Op. 45. This work is not based on a complete 12-tone row but on four seemingly different hexachords (Ex. 12, p. 216), each of which has a single mirror at a different point of inversion.[7] The four different points of inversion — fifth, minor second, major seventh, major sixth — are quickly understood as soon as it is recognized that, within each of the four groups, the series of intervals resulting from vertical combinations of tones of the original and its inversion are always the same (Ex. 13). Thus the interval partners of all four groups are identical. No matter to what positions in Groups II, III, or IV the notes of the original or mirror inversion of Group I are shifted, their partners accompany them. In this way we can prove the derivation of Groups II, III, and IV from I. The "classical" principle of the inviolability of the fixed order of tones in a row has been replaced by the more flexible concept of the hexachord as an aggregate unity subject to permutation. Thus while "new" surface arrangements may be effected, they turn out to be permutations of a basic order.

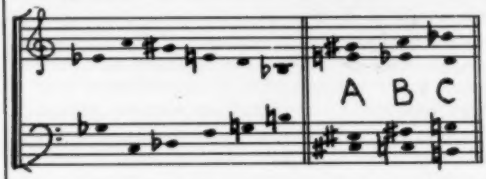
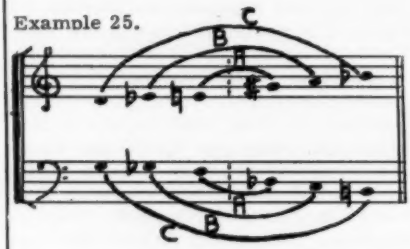
It is essential to our discussion to analyze in some detail the properties of the basic hexachord and mirror of Op. 45. In its given order, the hexachord comes under the first class of tropes, those which invert at one level. The different points of inversion noted in Groups II, III, and IV do not alter this fact, because they are interval partners of Group I and therefore are regulated by the relationships inherent in Group I. However, if we reverse the partner relationship of C♯ of the basic hexachord and G♯ (or A♭) of its mirror, we find that the hexachord has moved into the second class of tropes, those which invert at two levels or two points of inversion (Ex. 14). Note that the second mirror simply permutes the notes of the first mirror. The horizontal interval meaning remains identical although, with the introduction of a new point of inversion, vertical interval partner-relationships necessarily become different. As a singly inverting hexachord, its half-trope form is shown in Ex. 15; but by exchanging the final C♯ for a final G♯ we alter the half-trope form to that shown in Ex. 16.

Obviously there is a considerable difference between the two forms. The new half-trope form is the first half of Trope 8 transposed; the original half-trope form is the second half of Trope 6. Curiously enough, Schoenberg derives harmonic properties from the basic hexachord of Op. 45 which are almost identical with or, at least, analogous to those he employs later in Op. 50b. As we pointed out, it is in Op. 50b that Schoenberg employs for the first time a hexachord which mir-

7. For a fuller discussion of these hexachords see the author's monograph [2, 4-5].

rors at two different levels of transposition or points of inversion. Ex. 17 (p. 221) shows the basic hexachord and two mirrors of Op. 50b. The half-trope form of the original is as shown in Ex. 18. We recognize this as the first half of Trope 8 and therefore identical with the half-trope form of the altered hexachord of Opus 45 where we exchanged C# for G#. In order to grasp more fully the meaning of this simple exchange of two notes, let us go back to the basic hexachord and mirror inversion of Op. 45 and form intervals out of each consecutive pair of notes in the horizontal order (Ex. 19). Compare this with the intervals formed out of each consecutive pair of notes in the horizontal order of the altered hexachord and its mirror (Ex. 20). Instead of the interval series ending with minor thirds, they end with minor sixths, each series expanding from a major third through a tritone to a minor sixth. Now compare Ex. 20 with the intervals formed in the same way from the hexachord and first mirror of Op. 50b (Ex. 21) and the hexachord and second mirror of Op. 50b (Ex. 22). If we change the positions of the first two pairs of intervals we produce an expanding series (Ex. 23) which is a transposition at the tritone of the altered form of the hexachord and mirror of Op. 45. It is noteworthy that much of the harmonic language of Op. 45, which is derived from its basic, unaltered hexachord with its single inversion, antedates and presages the harmonic language of Op. 50b, based on a doubly inverting hexachord. In fact, if one were to abstract from the musical context of Op. 45 the 4-note chords resulting from the vertical combinations of the interval series shown in Exx. 19 and 20, it would be impossible to distinguish them from the similarly abstracted 4-note chords from Op. 50b except as transpositional analogues of each other. Schoenberg discovered a new harmonic technique, other than the technique of adjacency, by means of which chords could be formed out of groups of 3 or more adjacent notes (the opening of the 1st movement of the Fourth String Quartet is the most often quoted example of this type of harmonic technique). In other words, out of the ever unfolding hexachord Schoenberg drew still more than a new melodic flexibility or a new sense of "tonality" as suggested by Richard Hill and Roberto Gerhard; he discovered a form of harmonic orientation which has such strange links with the past that we are suddenly shocked by our own discovery of this fact and begin to wonder if, instead of taking a new direction, we have taken a long circuitous route only to return to something we thought we had left behind for good.

Closer inspection of the paired interval series of Op. 50b discussed above will give partial justification for the last remark (Ex. 24, p. 220). First, it is important to note how each interval series hinges on the 2nd interval (marked B), the most ambiguous of all intervals, a tritone; how a sense of resolving motion greets us at the conclusion of each series (at C). The tritone links significant elements of chords (using the analytical language associated with classical tonal harmony) whose key centers, taking A & B as tonics, are a tritone apart: E major — B^b major; C# major — G major. The tritone relationship is the necessary result of having combined the three-note groups of the half-tropes of the basic hexachord and mirror, the first notes of which are a tritone apart (Ex. 25). In the original series the ambiguous interval B resolves as well to interval A (change E_b to D# enharmonically)

Example 24.

Example 25.

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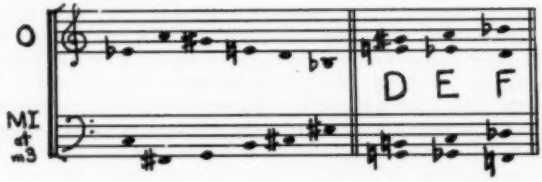
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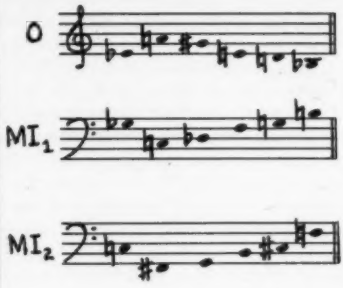

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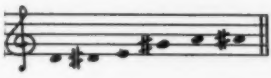

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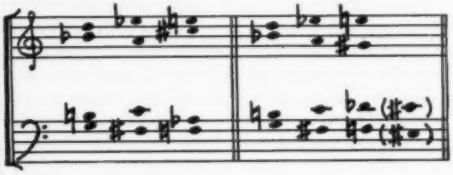
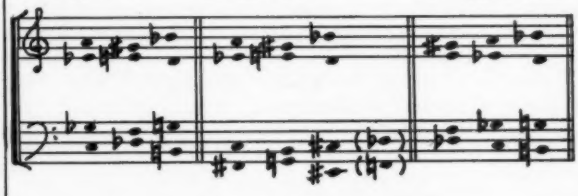

Example 20.

Example 21.

Example 22.

Example 23.

as it does to interval C; the same is true for the mirror series (change C to B# enharmonically to produce the resolution to interval A). In effect, we are dealing with leading-tone "modulations."

How are we to understand the 4-note chords which result from the vertical combination of the two interval series? Chords A and C contain major and minor 3rds if we take C# as the root of Chord A and G as the root of Chord C. Again, as in each interval series, we note how Chords A and C hinge on Chord B, a diminished chord, and also how a sense of resolution arises out of the progression from A to C. Even though Chord C's bass does not provide us with its root-tone, the G appearing in the tenor, the sense of resolution remains undisturbed and we feel we have effected a satisfactory "modulation," not from C# major to G major, but, rather, from a chord analogous to C# major or minor to a chord analogous to G major or minor. Anyone familiar with harmonic practices of that school of contemporary composers who have maintained the triadic concept of harmony will immediately recognize the mixture of major-minor as a fairly common chord-structure; from still another contemporary point of view, not to be taken too seriously however, there is present here an aspect of "bi-tonality."

Further investigation of this harmonic aspect leads us to a consideration of the interval series and resultant 4-note chords derived from the hexachord of Op. 50b and its second inversion at the minor third below (Ex. 26).

A new set of 4-note chords is produced because the notes of the second inversion are arranged in a different order from that which they assumed in the first inversion and consequently a new partner relationship has been established with the original. Notwithstanding, an analogous harmonic situation results: chords D and F, taking E as root of Chord D and B_b as root of Chord F stand in the same tritone relationship as did chords A and C. Chord E, a diminished chord, functions as a link between chords D and F as did Chord B between Chords A and C. This persisting tritone relationship is no accident. Trope 8 is organized so that each hexachord is arranged in two groups of 3 consecutive semitones, the first notes of which are a tritone apart; these groups in the first half of Trope 8 are also the 1st three notes each of the 1st and 2nd half respectively of Trope 1 which is the basic chromatic order (Ex. 27). It must follow then that chord structures of the type we are considering here are organically related to hexachords derived from Trope 8 and also, as demonstrated earlier in relation to Op. 45, hexachords derived from Trope 6; although in the case of Trope 6 the expanding series is not identical with that of Trope 8 while the aggregate chord-structures, read vertically, assume the same meaning as if they had been derived from Trope 8.

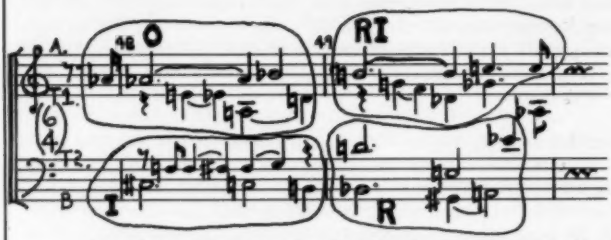
The organic derivation of chords from symmetrically inverting hexachords is neither "arbitrary" nor "accidental." Instead we are dealing with an inherently organic law of 12-tone harmony directly related to the principle of the hexachord, itself an inherently organic law of 12-tone row construction. The link between them is indissolubly forged in the natural order of symmetrical relationships. What we originally took to be purely an horizontal order offers us at the same time a vertical order, both deriving from a single source. Schoenberg stands completely justified; for it was he who said that the artist "will

wish to know consciously the laws and rules which govern the forms which he has conceived as in a dream.' Strongly convincing as this dream may have been, the conviction that these new sounds obey the law of nature and of our manner of thinking[8] — the conviction that order, logic, comprehensibility and form cannot be present without obedience to such laws forces the composer along the road of exploration" [4, 106-7].

A question inexorably forms itself as a result of our analysis: Is it possible that 12-tone practice has evolved into a system which organically includes within its potential scope significant aspects of earlier tonal practice? In attempting to answer this question one must remember that 12-tone practice inevitably includes far more than these aspects of tonality and is therefore in a more highly advanced state of pitch-organization, standing in relation to historical tonality much as a higher form of biological organism stands in relation to a lower form from which it has evolved and whose most significant functions it has incorporated within itself while discarding those which have proved unnecessary and extraneous. While we are not yet in a position to do more than speculate about the answer to our question, the evidence at hand offers sufficient ground for inclining toward a positive rather than a negative response. What we have discussed strongly suggests that equal-tempered chromaticism, organized hexachordally, incorporates in an organic way fundamental tonal functions having to do with the connection between intervals while discarding the exhausted machinery of historical tonality. We might point out with slightly more emphasis than before that whole-tone music, which was historically one of the first giant steps toward "atonality" because of its utter suspension of key-center feeling, was never theoretically grounded; it was merely accepted. I called attention earlier to Trope 44 as the theoretical ground on which we can establish whole-tone music. How much more will we eventually be able to discover in hexachordally organized chromaticism? Certainly it is not possible to turn the situation around and say that the material we have discussed indicates that whole-tone music, for example, and 12-tone practice are merely extensions of historical tonality. This would be patently absurd since it is impossible to refer symmetrical relationships back to classical diatonicism which has none. We prefer the probability that 12-tone practice as evolved by Schoenberg is a new order, a higher function of pitch-organization than historical tonality in which tonal functions, as vestigial symbols of the final distillation and metamorphosis of historical tonality, are organically inherent.

It is time now to turn to the actual music of Op. 50b and Op. 45 in order to observe the harmonic phenomena which we have presented

8. This is one of the few references I know by a musician to the close relation between the structural characteristics of the human mind and music. Most musicians either forget this or don't know it. As a result, they make the error perpetually of referring music only to "nature" and "natural laws" as if the human mind itself were not a part of nature — nature made aware of itself.

Example 28.

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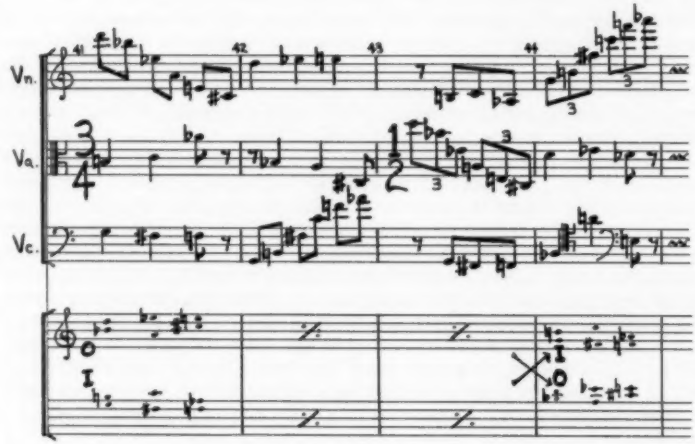
Example 29.

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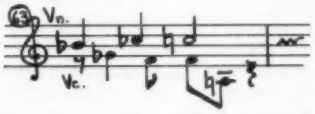
theoretically, functioning in their natural musical setting. The passage from Op. 50b given in Ex. 28 (p. 224) will serve as a beginning.

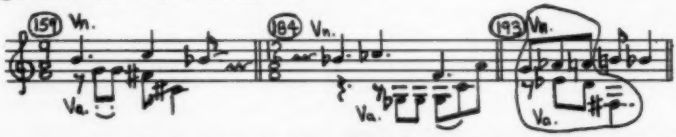
The reader will have no difficulty establishing a connection between this passage and the harmonic progressions discussed above. Such differences as are brought about by the use of retrograde forms and held-over tones are musically important, of course; but, analytically, the harmonic character remains essentially the same. Of particular interest is the freedom with which Schoenberg shifts the positions of notes of his basic hexachord and mirror without altering their structure or harmony. As it happens, because of the enormous variety of treatment which the hexachord undergoes in Schoenberg's hands, the above passage is the only one in Op. 50b where the particular harmonic progression we have been investigating is presented so unequivocally. In Op. 45 the incidence of this progression is more frequent. It makes its first clear-cut appearance in m. 41 (Ex. 29, p. 224).

Mm. 41 and 42, 43 and 44 are symmetrical inversions of each other with only a slight but important rhythmic alteration from m. 41 to m. 42, while from m. 43 to m. 44 rhythmic as well as intervallic alterations take place. The basic harmonic progression,[9] shown underneath the music, remains the same except for m. 44 where the positions of the original and mirror are inverted. The rhythmic shift which occurs in m. 42 between the violin and viola becomes characteristic of a two-voice motive in which we recognize the 6-note interval-series which may be either the upper or lower half of the progression of chords resulting from a vertical combination of hexachord and mirror (Ex. 30).

Example 30.



In varied form we find this two-voice motive later in such passages as those shown in Ex. 31.



The functions of the two 6-note interval-series which comprise the total harmonic unit are here clearly divided between melody and accompaniment. This concern for articulation of texture was constant with Schoenberg. In the essay, "Composition with Twelve Tones," Schoenberg said [4, 117]:

> The set is often divided into groups; for example, into two groups of six tones, or three groups of 4, or 4 groups

9. Obviously, this particular harmonic progression is not the only one to be found in Op. 45. Other kinds of harmonic progressions are developed but they fall outside the scope of our present study.

> of 3 tones. This grouping serves primarily to provide a regularity in the distribution of tones. The tones used in the melody are thereby separated from these to be used as accompaniment, as harmonies or as chords and voices demanded by the nature of the instrumentation, by the instrument, or by the character and other circumstances of a piece. The distribution may be varied or developed according to circumstances in a manner comparable to the change of what I call the "Motive of the Accompaniment."

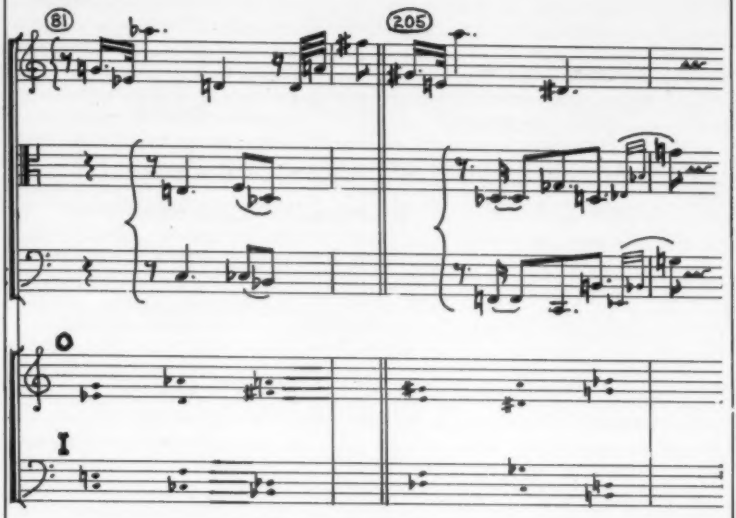
Again in a letter to Joseph Rufer dated April 8, 1950, he made these remarks [3, 95]:

> Personally I endeavor to keep the series such that the inversion of the 1st six tones a 5th lower gives the remaining 6 tones. The consequent, the 7th to the 12th tones, is a different sequence of these second six tones. This has the advantage that one can accompany melodic phrases made from the 1st 6 tones with harmonies made from the 2nd 6 tones without getting doublings.

The word "doublings" in this context strikes us with particular force. Throughout the essay from which we quoted a moment ago Schoenberg points out his avoidance of octave-doublings based on the idea that such doublings tend "to emphasize, and an emphasized tone could be interpreted as a root, or even as a tonic; the consequences of such an interpretation must be avoided [4, 108]." Schoenberg's intuition was absolutely right but he supports it I believe, with the wrong reason; for in 12-tone music (as in the earlier "atonal" music) the octave-doubling tends to weaken sonority rather than to strengthen it or to emphasize it to the point of suggesting to our ear that the doubled note is a root or tonic.[10] On the contrary, the aural effect of such doublings is to create holes and soft spots in the sonorous tissue — ample reason for avoiding them. Webern's solution, the unison-doubling, is, on the other hand, an ingenious solution to this problem and avoids the tendency to weaken sonority. It merely produces note repetitions. Schoenberg's reason for avoiding octave-doubling is couched in terms which reveal his historical position and as such proves the weakness of prejudices based on "local conditions." Nevertheless, we believe in his intuition. The consequence of his intense desire to avoid the octave-doubling was the inevitable discovery of the very material we are discussing in this article: the non-doubling hexachord-mirror combination, the non-doubling antecedent-consequent relationships and all their manifold ramifications.

Beside the conscious avoidance of octave-doubling exerting its force on the direction of Schoenberg's thought we might well consider too his innate contrapuntal penchant as a concommitant, unconscious pressure playing its role in leading him to the discovery of the new

10. Possibly the "weakening" of sonority is effect, not cause; and underlying the necessity to avoid the octave-doubling is a deeper reason having to do with the inherent structure of symmetrical relationships in which, since we are dealing with equal halves of a total, an imbalance results from weighting one of the halves more than the other.

Example 32.

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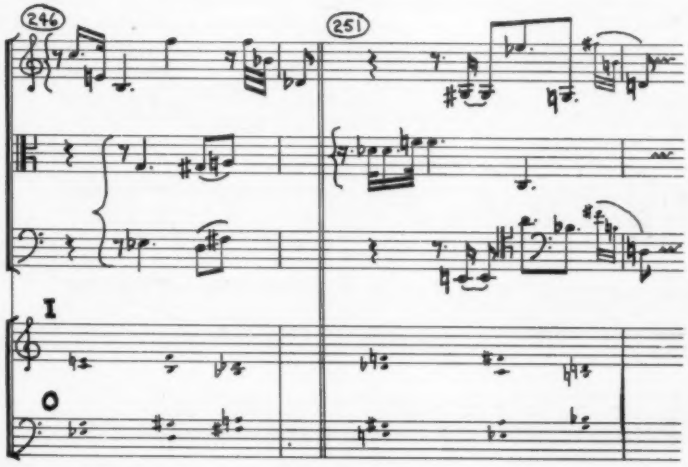
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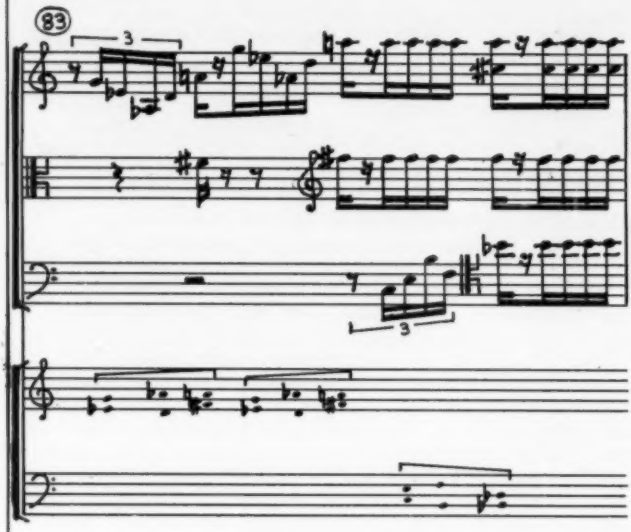
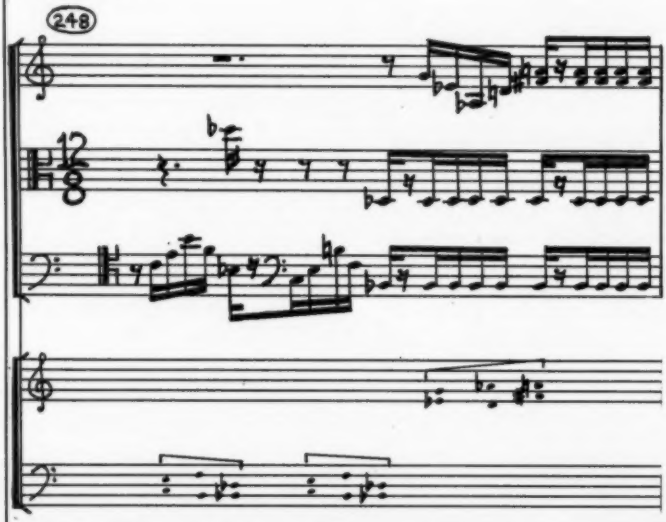
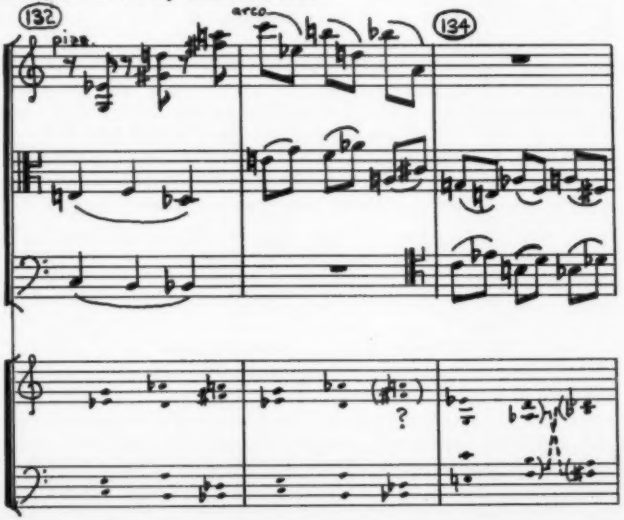

Example 35.

harmonic principle deriving from the hexachord. As early as Op. 11 it is possible to observe his penchant for combining short motifs in two or three voices which, though distinctly contrapuntal, produce a clearly defined harmonic character. Op. 23, No. 1 is an especially good example of this interpenetration of the horizontal and vertical. When Schoenberg began, therefore, to take row segments and combine them as we observed in the examples from Op. 45 (m. 159, m. 184, m. 193), it was not too much of a step to realize that these horizontal combinations were at the same time a form of harmonic combination also inherent in the row.

Returning from this digression we note other uses of material similar to the examples quoted above. Comparing Exx. 32 and 33 (p. 227) we note that the transpositions are the same but the positions of hexachord and mirror have been inverted. Measure 246 symmetrically inverts m. 81 as m. 251 does m. 105.

Still another form of the vertical combination of hexachord and mirror is shown in Ex. 34 (p. 228). The last chord suddenly assumes the voice disposition of the last chord of a doubly-inverted hexachord; F♯ exchanges with C♯. In this instance however, it is doubtful that this was the reason for the new coupling of intervals. It seems more reasonable to assume, considering the greater ease with which the violin can produce the C♯ as a double stop with A than the viola or cello can produce the C♯ as a double stop with their respective notes, that this "appearance" of a chord suggesting a doubly-inverting hexachord is pure accident (in the sense that it is not intentional). In Ex. 35 (p. 228) we find a variant of the same structure. In Ex. 36 (below) we note still other ways of varying the basic progression of chords. The intervals of each series of hexachord and mirror are alternately dovetailed in m. 132-133 while in m. 134 they criss-cross.

Example 36.

GEORGE ROCHBERG

Unquestionably, with Op. 45 and, later, Op. 50b Schoenberg was able to put to artistic use his discovery of the harmonic tendency, the inherent vertical order of the hexachord. This was simply another concentric circle, one of the last, flowing outward from his initial discovery of the possibility of ordered chromaticism, the method of 12-tone composition. In his works we can trace the major part of the history of the method: the rudimentary concept of the row as an inviolate order of 12 semitones; the division of the 12 into groups of 3, 4, and 6; the emergence of the hexachordal row with cross-related mirrors based on a symmetrical order; the metamorphosis of the old, inviolate order of 12 into the aggregate unit of the hexachord within which individual tones could shift position freely without affecting the inherent order of the unit; the discovery of the law of invertibility coupling interval partners in hexachord and mirror as well as determining the degree of the mirror function, whether single, double, triple, or sextuple, of the hexachord; and finally, the discovery of the harmonic tendency of the hexachord-mirror combination resulting in a new concept of vertical order.

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THE EVOLUTION OF RAMEAU'S HARMONIC THEORIES

by

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Before making a systematic study of Rameau's theoretical works, it seems advisable to present a brief summary of these works in chronological order. The first work, Traité de l'Harmonie Reduite à ses Principes naturels [T], appeared in 1722. It contains a rather disorganized theoretical system which is derived apparently from one principle, the first six partials of a vibrating string, which are referred to collectively as the senario. As the intervals obtained from this source will not produce all possible chords, another theory, that of mathematical manipulation of thirds, is introduced. This theory is an outgrowth of the first in the sense that Rameau observed that chords in their fundamental positions formed a structure of thirds; but when this theory is applied extensively, it produces some contradictions with the first principle. The treatise deals first with intervals, then chords, then chord successions; everything is ostensibly derived from the senario.

The Nouveau Système de musique theorique [NS] was written four years later. During these years, Rameau became acquainted with the phenomenon of the resonant body, which he discovered produced the same overtones as did the harmonic divisions of a string. This seemed to confirm Rameau's theories, since the sounds corresponding to string divisions were shown to be an inherent part of musical sound itself. The consequences of this discovery are not realized in this work, but are to be very important in succeeding works. One important advance, however, is the concept of the subdominant, which root was formerly called merely the "4th note." This is postulated but not scientifically determined. In connection with this chord, the theory of double-employment, which persists throughout Rameau's works, is advanced.

The next important work, Dissertation sur les différentes métodes d'accompagnement [Diss] is, as its title implies, more practical than theoretical. Its purpose is to show how the mechanics of music can be learned relatively easily if one understands the concept of fundamental harmony. It contains no advance over the theoretical principles of the Traité or of Nouveau Système. It is, however, significant in that it shows that Rameau is not thinking merely in abstract terms; practice and experience are constantly influencing his theoretical viewpoint.

Generation harmonique [G], which appeared in 1737, is important since it represents an essentially erroneous theory based on the misobservation of a scientific experiment. Rameau seemed to discover the co-vibration of strings whose lengths were multiples of that of an agitating string. (This discovery would imply similar properties in the resonating body, destroying utterly the concept of the fundamental as the lowest tone of a partial series.) Ignoring these potential difficulties,

Rameau plunges into a "scientific" justification of the subdominant.

It is not until 1750 that Rameau corrects this error in his Démonstration du principe de l'harmonie [Dem]. The long string is caused to vibrate by an agitating string of whose length its length is a multiple, but this longer string vibrates only in segments corresponding to the unison of the agitating string. This, unfortunately, leaves the subdominant without any basis in fact. Rameau concludes that nature gives the indication that there is a relationship between one string and another several times as long; in other words, the subdominant is a product of art.

Nouvelles réflections de M. Rameau sur la Démonstration du principe de l'harmonie [NR], which appeared in 1752, contains philosophical and experimental discoveries. In the first instance, Rameau tries to establish a connection between music and architecture in the sense that natural proportions are the basis for both. Totally unrelated are the experiments with brass instruments, which only serve Rameau as further proof that only the first six partials are in tune. The sounds of the subdominant can be found only so high in the partial series that they are also out of tune. This proves to Rameau that the tonic and dominant are superior to the subdominant, but it does not lead him to reject the latter (as he did the 7th partial).

In the Observations sur notre instinct pour la musique [Obs], 1754, Rameau discusses his basic concept that melody originates in harmony, and harmony alone is instinctive to man. In this connection he makes many observations about the effect of certain harmonies on the ear, and the emotions produced by these effects.

The Code de musique pratique [C], 1760, is another volume of principles of accompaniment; but at this point in his life, Rameau seems anxious to clear up obscure points in his theories. The work remains a practical one, and therefore it contains as concise and precise a statement of theories as is possible for Rameau. One stumbling block thus far was the conflict between the harmonic generation of chords and the construction of chords by added thirds. Rameau admits for the first time that the melodic phenomenon of suspension may be the explanation for certain chords which exceed the range of an octave. The latter part of the Code is entitled Nouvelles Réflexions sur le Principe Sonore; it is more abstract than the rest of the Code, and can be considered Rameau's final pronouncement of his theories. Rameau forcefully rejects former statements he had made as a result of the mistaken idea of undertones. He reaffirms his original position that everything in music comes from one single principle and rejects the idea that any chords can be merely a product of art. He is therefore obliged to consider tones as far removed from the fundamental as the 45th partial. It would seem that at this point Rameau is sacrificing musical sense in order to build a more nearly complete, rational system.

The final work, Origine des Sciences [Or], was published in 1762. Here again Rameau is writing in a philosophical vein, giving reasons for people's feeling for a tonic sound, for melodic inflection, and especially for fundamental harmony.

Throughout his works, Rameau clings to several basic ideas. He maintains that all music, even unaccompanied melody, has its foundation in harmony. Harmony is not determined arbitrarily, but arises

from a definite principle. Rameau's ideas about the exact nature of this principle change as his theory matures. At first, he refers to the senary division of a string, whose fundamental sound is represented by unity. After learning about the harmonics of the resonant body, Rameau refers to the fact that a single musical sound contains these partials in itself.

Rameau is fascinated by the mathematical aspect of the physics of music. This is evident throughout his thinking. His earlier works make considerable use of mathematical calculations of intervals and chords; later works deal more with acoustical phenomena than with pure calculation. In the Traité, Rameau reverses the harmonic proportions of the intervals, since he feels the reader can better understand integers. This is useful with respect to the overtone series alone, but when he pretends to discover the co-vibration of multiples, it becomes confusing.

However preoccupied he may be with the intricacies engendered by his system, Rameau remains essentially a musician. If his theories lead him to conclusions that experience proves incorrect, he seeks other explanations, even if this means destroying his system. The fact that Rameau sees the faults of his theories and is constantly seeking improvements shows the honesty of his approach. He is more interested in discovering the truth than in building a system.

Rameau defines an interval as the distance between a lower and an upper sound [T, 2]. The intervals arise from the partial series in an order of decreasing perfection; i.e. the octave, 1:2 (found between partials 1 and 2), is more perfect than the next interval, the fifth, 2:3 [T, 5]. The intervals will be discussed in this order.

The octave's importance in Rameau's theories cannot be overemphasized. He considers two notes an octave apart almost identical; in this respect he cites, for example, the fact that men and women sing in octaves, thinking they are singing the same note [T, 6]. This he maintains throughout his life. In 1753, in response to a criticism from Euler, a physicist who claimed that since 1 and 1/2 are not identical the octave is distinct, Rameau states that for all practical purposes in harmony it may be regarded as a "replica."[1] The consequences of this are many. The octave serves as boundary to all the other intervals [T, 7]. From this results the possibility of the inversion of both intervals and chords.

The fifth is the next interval to be engendered. Since it is the first interval to contain a sound distinct from the fundamental, it is the basis for harmony. The fourth (3:4) is engendered next, but it is the difference between the fifth (2:3) and the 4th partial, which represents the second replica of the fundamental [T, 10]. This is the first example of the principle of inversion.

The major third (4:5) and its inversion the minor sixth (5:8) cause Rameau no trouble. His attempt to explain the minor third foreshadows difficulties which present themselves throughout his theories. The

1. Extrait d'une Réponse à M. Euler [cited in Shirlaw, 274].

minor third (5:6) is the first interval which does not come directly from the fundamental; i.e. neither of its sounds is a replica of the fundamental [T, 13]. Nevertheless, Rameau determines the major sixth by doubling the lower sound, represented by 5, making the proportion 6:10. He remarks naively that "the principle of the minor third seems to be different from that of the major third."[2]

Rameau has thus followed his predecessors, Zarlino and Descartes, in deriving consonances from the senario. But his principle of inversion makes him see the consonances in a new light: "there are only three primary consonances, which are the fifth and the two thirds ...from which come three secondary consonances, which are the fourth and the two sixths...."[3] This statement reveals a corollary of the theory of inversion, that a primary consonance can never be regarded as the inversion of a secondary; the secondary depends for its definition on the primary. This is confirmed by the fact that, with the exception of the fourth, all the secondary intervals depend on numbers outside the senario: the minor sixth on 8; the major, on 10. This theory of consonant intervals and their origin is not modified in any way throughout Rameau's work, for what has been said about harmonic division of a string applies equally well to the resonance of a sonorous body.

The explanation of dissonance is a problem which confronts Rameau throughout his theories. The first explanation he offers is entirely mathematical: finding the difference between consecutive consonances [T, 22-3]. Thus the fifth (2:3) less the fourth (3:4) gives the major tone (8:9); etc. He then proceeds to construct many other dissonant intervals (the minor tone, semitones, tritone, etc.) by adding, squaring, and cubing intervals and by inverting these products. Another method of calculating dissonant intervals is offered later in the Traité: the method of altering consonances chromatically [T, 166-7]. In this way Rameau produces such oddities as the diminished octave, the augmented sixth, etc., for which he apparently finds no practical use.

These methods are purely theoretical; Rameau enumerates possibilities but does not draw any conclusions about them. In later works he finds the source of dissonance in chords and in chord progressions, — obviously these early definitions did not satisfy him. He cannot seem to decide whether the seventh or the second is the actual source of dissonance. In the Traité, he even calls the seventh a fundamental interval (in conjunction with the fundamental bass) [T, 24].

Strangely enough, Rameau sees the connection between dissonance and the acoustical phenomenon of beats in his Generation. He states that the rapidity and frequency of beats occurs in connection with dissonance, and the cessation of beats with consonance; the rapidity of beats increases as the two sounds in question approach a state of consonance[G, 17].

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2. "Le principe de la Tierce mineure semble être different de celuy de la Tierce majeure... [T, 13]."

3. "Il n'y a que trois Consonances premieres, qui sont la Quinte et les deux Tierces... d'où proviennent trois Consonances secondes, qui sont la Quarte / et les deux Sixtes... [T, 13-4]."

Rameau discusses the more practical aspect of dissonance with respect to chords of the seventh and their resolution and with respect to his ideas of a key-scheme. One notes that he does not deal with many of his theoretical intervals in this connection; nowhere does he treat of the chords of the augmented sixth, although Shirlaw states that three forms of that chord were known in Rameau's time [Shirlaw, 241]. Rameau is aware of the existence of this chord in practice; for in a later work he includes it in a list of figured-bass chords [Diss, 2]. Rameau sets his own limits in a discussion of the fundamental bass in Nouveau Système; he states that since the fundamental bass in fifths and thirds produces no interval smaller than the chromatic semitone, it is unnecessary to deal with such smaller intervals [NS, 52].

Rameau has thus derived both consonances and dissonances directly and indirectly from the senario, or the first six partial tones. As were his predecessors, Rameau is wary of the 7th partial. In the Traité he says he has excluded it because it "cannot produce any pleasant-sounding interval."[4] In the Generation he states that the 7th, 11th, and 13th partials are "always out of tune!"[5] In the earlier work he justifies his statement by saying that all musicians will agree about this. In the latter work he offers a more scientific demonstration. Any sound containing more than the partials 1, 3, and 5 cannot be appreciated by the ear. The "6th experiment" in Generation describes a pair of tongs suspended on a thin piece of twine, the ends of the twine applied one to each ear. When the tongs are first struck, one hears a confused jumble of sounds. As the upper partials die away, the lowest sound begins to be audible, along with its twelfth and seventeenth [G, 17-8]. In another experiment involving the resonance of violoncello strings, Rameau demonstrates that the 7th partial is very weak [G, 10]. Throughout his work Rameau excludes the 7th partial as a source of any interval.

Rameau states three principles in defining a chord: (1) that it may not exceed the range of an octave, (2) that the fifth, engendered next after the octave, is the basis of all chords, and (3) that either of the two thirds may determine the construction of the chord [T, 32].

The only chord coming directly from the senario is the perfect major triad, 4:5:6. The 4, being a replica of the fundamental sound, may be doubled without changing its meaning; therefore the perfect chord may exist in the arrangement, 5:6:8. Similarly the third, represented by 5, may be raised to its octave, producing another arrangement, 6:8:10. This application of the inversion theory renders the chord less perfect, but still consonant [T, 34-5]. Rameau sees a confirmation of the principle of nature as he had observed it in the senary division of a vibrating string when he discovers the perfect chord inherent in any resounding body, even the human voice [NS, iii].

The first two principles of chord derivation come directly from the senario; the third does not. Rameau at this point allows himself some liberty. He observes that the perfect chord consists of a fifth divided into two thirds. Therefore he concludes that if he multiplies two thirds, and a fifth results, he has obtained another "perfect chord."

4. "Ne pouvant donner aucun intervale agréable... [T, 4]."
5. "Toujours faux... [G, 62]."

His calculations supply him with the "perfect minor triad," 20:24:30 (or 10:12:15) as well as the "perfect major triad," 20:25:30 (or 4:5:6) [T, 30]. The minor triad can be inverted according to the same principle as the major triad [T, 36]. Rameau refuses to follow Zarlino's example in regarding the minor harmony as an inverted major (6:5:4), for this is contrary to his principle of deriving intervals from the harmonic division of unity [T, 19]. His present explanation does not completely suit him, for he modifies it considerably in subsequent works.

In the Generation he states mistakenly that a given string may cause to vibrate other strings, which are its multiples in length, at their respective fundamentals [G, 8-9]. This would imply a series of potential "undertones" in an inverse proportion to the overtones.[6] Accordingly, a fundamental C would generate F—Ab—C; thus Rameau arrives at Zarlino's point of view. Unfortunately this threatens the basic premise that the fundamental is the lowest note of the series it generates.

In the Démonstration, Rameau admits he has erred in his observation of the co-vibration phenomenon. The longer string will be caused to vibrate only in segments corresponding to the unison of the exciting string [Dem, 21]. Nevertheless, he continues to derive the minor according to the descending proportion 6:5:4, maintaining he is deriving it from a natural principle. The major harmony is a direct product of nature; the minor is only "indicated by nature," and is therefore in a sense the result of art. It should always be subordinate to the major harmony and be regulated by it [Dem, 62-4].

Towards the end of his life, Rameau comes to the conclusion that all harmonic phenomena are directly related to a single natural principle, the famous "Principe Sonore." The minor is not a result of mathematical hypotheses nor purely a product of art. It can be found in the partial series at 10:12:15 [C, 202].

In the Traité Rameau finds that the square of the major third produces an augmented fifth, while that of the minor third produces a diminished fifth. They are "not chords" since, according to his definition, no complete chord exists without a perfect fifth composed of the two kinds of thirds. "If the fifth is not heard in a chord, the fundamental is consequently inverted, sub-posed[7]...i.e. added beneath the chord ..., or borrowed... i.e. chromatically altered from its actual root ...; or else the chord would not be complete, in which case it would be worthless..."[8] This rather narrow view is modified later in connection with the fundamental bass, when Rameau states that the chord of the augmented fifth may appear only on the mediant of a minor

6. "Le Corps sonore ne se borne pas à la génération de ses soumultiples, il engendre encore un pareil nombre de ses multiples en même rapport avec lui à l'inverse... [Obs, 35]."

7. "Supposé" formerly could be translated exactly by its cognate, "supposed." Since the meaning "placed beneath" has become obsolete in English, we have coined the word sub-posed to avoid any connotations of "imagined" or "understood."

8. "Si la Quinte ne se fait point entendre dans un accord, le fondement en est pour lors renversé, supposé, ou emprunté; ou bien l'ac/cord ne sera pas complet, sinon il ne vaudra rien... [T, 30-1].

key [T, 273]. The concept of a chain of fifths as a typical fundamental bass progression led Rameau to admit the diminished triad as a chord.[9]

In addition to the "perfect" chords and to the unstable ones, other chords still to be found within the range of an octave are the 7th chords. (These are all dissonant, but nevertheless have varying degrees of perfection.) Rameau finds that there are five possible 7th chords, all products of different ways of arranging thirds. Of these the most perfect is the perfect major chord plus a minor third.[10] He states that "it seems made in order to render even greater the perfection of the consonant chords...because the perfect...should always follow it."[11] He demonstrates this chord with its inversions; in its fundamental position 20:25:30:36 (not 4:5:6:7!) and in its three inversions 25:30:36:40, 30:36:40:50, and 36:40:50:60 [T, 37]. The importance of this chord becomes especially evident in connection with fundamental bass progression, and with the determination of a key system. It also serves as a model for the treatment of dissonances.

One result of Rameau's long preoccupation with his theoretical system is this: as he builds a complex system out of a few basic materials, he proceeds to re-define the basic materials in terms of this system. Thus in the Nouveau Système he defines the dominant-7th chord as a joining of both dominants into a single chord, which therefore possesses an even stronger tendency toward the tonic [NS, 60]. In the Code, Rameau refers to the dominant seventh as the conjunction of the extreme terms of the triple progression, producing an absolute determination of a key [C, 210]. (These advanced concepts will be discussed in detail in connection with key-systems.)

The second type of 7th chord is the perfect minor triad plus a minor third, with a ratio of 10:12:15:18 [T, 39]. This formation is to be of great theoretical importance, but Rameau does not realize this in the Traité. He constructs the inversions but does not remark that the 1st inversion is a major triad with an "added" major sixth, a chord which is much more stable than the "fundamental position." In the Nouveau Système, where the discovery of the subdominant is expounded, Rameau refers to this "chord of the added sixth" as being fundamental, and second only to the dominant discord in importance [NS, 60-1].

The third 7th chord is the perfect major triad plus a major third, 8:10:12:15 [T, 40]. Rameau remarks that this chord does not sound so good as the major triad plus a minor third, then refers to it as "accidental...the result of modulation."[12]

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9. "Il n'y a pas un Ton qui ne reçoive dans sa marche une fausse-quinte au lieu d'une quinte...[C, 95]."

10. Rameau does not distinguish sevenths by the terms "major" and "minor"; these terms he reserves for thirds and sixths only. The seventh in this chord has no qualifying adjective; the so-called major seventh Rameau calls an augmented seventh [T, 164-6].

11. "Il semble être fait pour rendre encore plus grande la perfection des accords consonans...parce que le parfait ou ses dérivés, doivent toûjours le suivre [T, 37]."

12. Rameau uses the word "modulation" in the following sense: "L'art de conduire un chant et son harmonie, tant dans un même Ton que d'un Ton à un autre...[C, 135]."

The fourth chord consists of a perfect minor triad with a minor third added beneath it, 25:30:36:45. (At this point Rameau did not recognize the diminished triad as a chord.) He refers to this combination, resulting also from modulation, as more tolerable than the third kind of 7th chord [T, 41].

Two possible 7th chords which Rameau omits from consideration are those involving an augmented fifth — 16:20:25:30 and 40:48:60:75. Their occurrence is explained as borrowed or sub-posed. This is strange, since he does permit the two 7th chords containing diminished triads, which he formerly rejected also as not being fundamental [T, 33]. He states that experience permits the occasional substitution of a diminished fifth for a perfect, but not of an augmented fifth.[13]

The fifth type of 7th chord is the diminished seventh. Rameau remarks that this chord can be inverted; he also makes the two contradictory statements that it is always divided by thirds, and that it is borrowed from the (dominant type) 7th chord by raising the fundamental a semitone [T, 42]! Therefore its fundamental position is "the chord of the augmented second" (B^b—C#—E—G, 108:125:150:180), the first inversion of which is "the chord of the diminished seventh" (C#—E—G—B^b) [T, 43]. In the Nouveau Système Rameau changes his mind about this chord, making it conform with other chords in that the fundamental position is an arrangement in thirds [NS, 7]. He states in the Generation that the "note sensible" ("sensitive note," i.e. the leading-tone) is the fundamental despite the diminished fifth; this is possible because this chord is derived from the dominant. The chord may be considered to consist of the third and fifth of the dominant chord plus the fundamental and third of the subdominant [G, 151]. This is another example of the use of an advanced theoretical concept to re-define a basic concept.

With respect to 9th and 11th chords, Rameau has this to say: "If experience proves that some chords exceed the range of an octave, reason tells us that the root must be contained within this octave,... therefore, so that the root should not be destroyed, it must be subposed by a new sound added below at a distance of a fifth or of a third..."[14] If experience tells Rameau that these combinations are usually found as suspensions, he does not explain them as such; for that would threaten his premise that melody originates in harmony. This presents a problem. "Sub-position has its origin in one sound of the arithmetical proportion... [the mistaken undertone proportion]... added beneath the harmonic proportion; suspension is only a result of this."[15]

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13. "L'experience nous prouve... que la fausse-Quinte occupe souvent la place de la Quinte dans les accords.... La Fausse-Quinte y est plûtôt reçûë que la Quinte superflue [T, 33]."

14. "Si par exemple l'experience nous prouve qu'il y a des accords qui excedent l'étendue de l'Octave, la raison...nous dit que le fondement ne peut subsister que dans l'étendue de cette Octave, ... pour que / ce fondement ne soit point détruit, il faut qu'il soit pour lors supposé par un nouveau Son ajouté au-dessous de luy, à la distance d'une Quinte ou d'une Tierce... [T, 32-3]."

15. "La Supposition prend sa source dans l'un des sons de la proportion Arithmétique ajouté au-dessous de la proportion / Harmo-

In the Code he yields somewhat: "Suspension is a kind of sub-position... some sounds which should descend together chase one another...."[16] He then makes the distinction that sub-position occurs only after the perfect chord, and suspension after a dissonant chord, "with the exception that a tonic can remain as a $\frac{6}{4}$ over its dominant as a suspension."[17] Once again basic concepts are modified by more advanced ones.

Rameau has thus derived all the chords from two basic ones: the "perfect major triad and the [dominant] 7th chord."[18] "by using a dubious method of juggling thirds. Despite this rather arbitrary system, one feels in the Traite that Rameau is not merely constructing chords, he is also looking forward to their use. The method of adding thirds becomes well established by the time of Nouveau Système, where Rameau remarks that "experience permits us to place whatever thirds we wish above one another, except that two major thirds may not occur in succession."[19] (i.e. conjunctly in the same chord). Towards the end of his life, Rameau forms a new theory of dissonant chords. Previously he could form E—G—B—D (10:12:15:18) by adding a 4th proportional value before G—B—D (12:15:18) or after E—G—B (10:12:15). Now, in the Code, he considers E—G—B—D the result of the conjunction of these two triads closely related by means of their common tones [C, 207]. This theory results from some advanced theories having to do with the double-employment of the super-tonic/subdominant and with the relation of a minor to its relative major. This theory and the revised concept of suspension to explain sub-position show Rameau's increasing tendency away from the mathematical manipulation of thirds.

In the second book of the Traité Rameau uses the idea of the fundamental sound, whose importance he has already discussed in the construction of harmonies. He defines bass as "the part where this fundamental sound belongs, because it is always the heaviest and lowest sound."[20] This is not to imply that all chords should be found in their fundamental position; for if they are in inversion, the fundamental bass is always "understood."[21] In the case of chords by sub-position, the added sound is always supernumerary, and the fundamental harmony does not include it; it can never be a tone of the fundamental bass.[22]

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nique; la Suspension n'en est qu'une suite [G, 158-9]."

16. "La suspension est une espèce de supposition...des sons... qui devroient descendre ensemble se chassent...[C, 59]."

17. "Excepté que l'accord d'une tonique peut rester pour donner celui de sixte-quarte à sa dominante en forme de suspension...[C, 59]."

18. "Il n'y a dans l'Harmonie que deux Accords, qui sont le parfait et celuy de la Septiéme...[T, 45]."

19. "L'expérience nous permet icy de placer telles Tierces que l'on veut à la suite l'une de l'autre, pourvû qu'il n'y en ait pas deux majeurs de suite [NS, 6]."

20. "La partie où regne ce Son fondamental, parce qu'il est toûjours le plus grave, et le plus bas...[T, 49]."

21. "Si la Basse fondamentale en est retranchée, elle y est toûjours sous-entenduë...[T, 57]."

22. "Le Son ajoûté...ne peut être regardé que comme sur-

Rameau cites Zarlino in formulating the general rule for the progression of the fundamental bass. The bass should proceed slowly with respect to the upper parts, moving by consonant intervals so that each sound harmonizes with the preceding sound. The upper parts should move diatonically and generally more quickly than the bass [T, 50]. Rameau goes beyond Zarlino in the distinction he makes between the fundamental bass and the actual bass, or basso continuo. The fundamental bass is not a sounding part, but is only given to show how the harmonies move.[23] The fundamental bass notes bear only triads and 7th chords, while the ordinary bass notes bear all kinds of chords (i.e. chords in root position and in inversion). "These chords compared to one bass or the other will be essentially the same"[24]; the fundamental bass therefore constitutes a means of checking the progressions of a continuo.

Rameau has previously stated that there are only two chords which are truly fundamental: the perfect, or tonic, and the 7th chord located on a root a fifth above it, which chord he calls the dominant-tonic. (Other chords are referred to simply as dominants [T, 68].) The most perfect progression involves these two chords: the bass descends a fifth, "returning, as it were, to its source."[25] Rameau calls this the "perfect cadence"; it is the model for all the progressions of harmony. "The perfect cadence is the origin of the principal varieties in harmony. One inverts this cadence, one 'breaks' it,[26] one interrupts it,[26] one imitates it, one avoids it; this is what constitutes the varieties."[27] The example of the perfect cadence shows that the best kind of root progression is a chain of dominants, which progression Rameau terms the "imitation of cadences."[28] To "invert the cadence" is to write a chain of dominants in which each chord is in the first inversion. The movement of the basso continuo will therefore resemble that of the fundamental bass in the "imitation of cadences." To "avoid the cadence" is to add a seventh to a chord that should be a resolution, thereby changing it into a dominant [T, 67-8].

Another important cadence is the reversal of the perfect; that is,

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numeraire, puisque l'Harmonie fondamentale y subsiste toûjours sans luy... la progression des Accords n'y est point alterée [T, 74]."

23. "La Basse fondamentale n'est donnée que pour connoître l'Harmonie et ses routes, nullement pour être entendue au-dessous des autres parties [G, 190]."

24. "Les Accords comparez à l'une ou à l'autre Basse soient toûjours les mêmes dans le fond... [T, 206]."

25. "Il semble que la Quinte retourne à sa source... [T, 129]."

26. These two cadences will be discussed later in connection with exceptional root movements.

27. "La seule cadence parfaite...est l'origine des principales variétés introduites dans l'harmonie. On renverse cette cadence, on la rompt, on l'interrompt, on l'imite, on l'evite, et c'est en quoi consiste ces variétés [C, 93]."

28. "Simple dominante,...suivie d'une autre dominante et ainsi de l'une à l'autre jusqu'à une dominante-tonique, après laquelle doit naturellement suivre la Tonique: cela s'appelle Imitation des Cadences [G, 175]."

the root ascends a fifth. This is termed the irregular cadence [T, 64]. "The irregular cadence cannot be varied, since it cannot be announced by any dominant."[29]

Consonant root movement, especially with the bass descending, is the general rule for fundamental-bass progressions. Exceptions to this rule are bass movements in seconds and sevenths. Rameau forbids any progression where the bass rises a seventh (descends diatonically) [T, 51]. As an example of a fundamental bass rising a second, Rameau cites the "broken cadence." In this case the chord which follows the dominant-tonic is on the sixth degree instead of the tonic. It is frequently found in the 1st inversion, so that the basso continuo descends a fifth to the tonic note; therefore it resembles the perfect cadence to a large extent [T, 61]. This cadence is the source of "license," by which a sudden transition to a root fairly distant from the expected one produces an effect of surprise. Rameau concludes that license can be employed if it is done in good taste [T, 110].

Rameau proposes a fourth type of cadence after he has done much thinking about major keys and their relative minors. This is the "interrupted cadence,"[30] in which a dominant-tonic in the major mode descends a minor third to the dominant-tonic of the relative minor. It could be considered a typical root-progression according to the conditions proposed in Traité, but it depends for its definition on a more advanced concept. It is an unusual type of cadence since it does not necessarily produce a release of tension.

Rameau maintains, even in the Traité, that only the tonic note should bear a perfect chord [T, 204]. On every other note of the fundamental bass there should be placed a dissonance. The dominant-tonic, when it does not precede the tonic, may bear a perfect chord. But in the perfect cadence, the dominant-tonic always bears its seventh and that dissonance which distinguishes it from simple dominants, the diminished fifth. The resolution of the dissonances in this cadence serves as an example for the resolution of all dissonances [T, 98].

First of all, one must determine which note of a chord is dissonant; according to the theory of the fundamental position of chords, it must be the seventh. Inverting the chord so that the fundamental appears a second above this note does not change the fact that it is the dissonant one [T, 98]. Rameau refers to the dissonance between the fundamental and the seventh as the minor dissonance, because it results from the addition of a minor third above the perfect chord [T, 45]. The minor dissonance is always prepared by a consonance, and can be resolved only on a third [T, 81]. Rameau states further that in the perfect cadence, if the seventh is not actually present in a dominant-tonic chord, it must be understood [T, 216].

Adding a seventh to a perfect major chord results in another dissonance, the diminished fifth between the major third and the seventh; Rameau therefore calls this the major dissonance. He states that the

29. "La cadence irrégulière n'est sujette à aucune variété, puisqu'elle ne peut être anoncée par aucune dominante [C, 95]."

30. "La cadence interrompuë"; Shirlaw translates "cadence rompue" as "interrupted cadence"; to avoid this confusion the literal translation "broken cadence" was used.

major dissonance never occurs without the minor one [T, 82]. Ordinarily it cannot be prepared, therefore it should be approached by step. It moves up a semitone, resolving on the tonic note or its octave [T, 57]. Rameau states that this resolution of the leading-tone upon the tonic is essential in a final cadence [T, 217].

These resolutions are in accordance with the natural progression of thirds (as stated by Zarlino): the major should ascend and the minor descend. The major third and the seventh of the dominant-tonic chord are "without exception" the origin, respectively, of all major and minor dissonances [T, 56]. Rameau thus shows that the fundamental bass concept can solve many problems regarding dissonance; his predecessors had made the mistake of only reckoning dissonances upward from the basso continuo. The resolution of these dissonances is not affected by the inversion of either chord of the perfect cadence. The exceptional progression of the "broken cadence" does not affect these resolutions either [T, 110].

It is only in conjunction with a falling fundamental bass that these dissonances may be prepared and resolved. In the most perfect progression (bass descending by a fifth or ascending a fourth), the third prepares and resolves the dissonance; in the next most perfect (bass descending by a third or ascending a sixth), the fifth; in the least perfect (bass descending by a seventh or ascending a second), the octave prepares and resolves the dissonance. If the bass ascends by these intervals, the dissonance cannot be prepared [T, 81-2]. Therefore, in the case of the irregular cadence (bass ascending a fifth), in order to obtain a dissonant combination on the first chord, a note other than the seventh must be added, namely the sixth.[31] Rameau states that in this cadence it is the property of the fourth note to bear the chord of the added sixth [T, 64]. This statement is as dogmatic as Rameau's previous declarations regarding the dominant dissonances, yet it is offered with no theoretical justification. Nor does Rameau explain why the (consonant) fifth requires preparation. This fifth remains fixed on the tonic note while the sixth resolves up to the third of the tonic chord [T, 65]. This resolution has nothing to do with the model resolutions of the major and minor dissonances.

Rameau presents, in Nouveau Système, a new concept regarding this "4th note"; since it is a fifth distant from the tonic, it is another kind of dominant, a subdominant [NS, 38, 60-1]. It should be altered by adding the sixth to produce a cadential effect with the tonic. This concept causes Rameau much worry when he seeks its acoustical proof. The difficulties thus encountered will be discussed in connection with key-systems.

Other problems than the acoustical ones arise when it becomes evident that the "subdominant chord of the added sixth" does not always proceed to the tonic. It frequently moves to the dominant, thus breaking the rule of consonant root movement. In the Démonstration, Rameau comments on the unpredictable nature of the 6th degree of the scale: it may represent the fifth of the 2nd degree or the third of the subdominant

31. In other words, Rameau does not consider a simple IV-I an effective cadence. In adding a dissonance to the first chord, he writes II^6_5-I instead of IV_7-I. He gives no explanation for this.

[Dem, 59]. This is clarified somewhat in Nouvelles Réflections, where the theory of double-employment, first proposed in Nouveau Système, is given its fullest explanation. In the mode of which C is generator, when A represents the fifth of D, it is a dominant, and it proceeds to the dominant-tonic (II^6_5 - V). In this case it is a 7th chord, of which C is the dissonant note. The first inversion of this chord does not change the dissonant quality of the C. However, when A represents the third of F, the chord is a subdominant, proceeding to the tonic. It looks just like a first inversion of the 7th chord on D, but it is actually in fundamental or root position. The sixth, D, is the dissonant note. "This dual origin of the sound La in the same mode... causes the double-employment, and prescribes its rules."[32]

In the Code, Rameau modifies his views on the treatment of dissonances. The seventh of a dominant-tonic chord does not require preparation; nor does any dissonance accompanying the "sensitive note" (the leading-tone); all others do require preparation [C, 72]. Rameau still maintains that the dissonant sixth of a subdominant chord does not need to be prepared, but the fifth (a consonance) does require preparation [C, 96].

The fact that the tonic note alone should bear the "perfect chord" singles it out as the most important root. In the Nouveau Système, Rameau states that other roots must be made dissonant in order to emphasize the importance of the tonic [NS, 56; T, 53]. This principle, which Rameau reiterates throughout his works, is the basis of tonality.

Early in the Traité, Rameau has demonstrated that there are two fundamental chords, the perfect major triad and the chord of the seventh. The most perfect progression of these two chords proceeds from the less perfect to the more perfect, from tension to repose [T, 53]. One calls the first chord of this perfect cadence the dominant-tonic, "because it should always precede the final note, and therefore dominate it."[33] One calls the final chord the tonic, "because everything begins and ends on it."[34] The note preceding the octave of the tonic is always the major dissonance. One calls this note the "sensitive note," because one "senses that the tonic note should always follow it directly."[35] Out of this perfect cadence, then, Rameau constitutes the major mode.

The tonic note "determines the progress of the other notes contained within its octave.... If we take C as tonic, we cannot alter the positions of the notes D, E, F, G, A, or B by sharping or flatting them,

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32. "Cette double origine du son la, dans le même Mode, où il peut être employé comme Quinte de ré, ou comme Tierce de fa, occasionne le double-emploi... et prescrit les règles... [NR, 27]."

33. "Parce qu'elle doit préceder toûjours la Notte finale, et par consequent la domine [T, 56]."

34. "En ce que c'est par elle que l'on commence et que l'on finit [T, 56]."

35. "Parce que l'on... sente que la Notte tonique, ou son octave doivent suivre immediatement apres... [T, 56]."

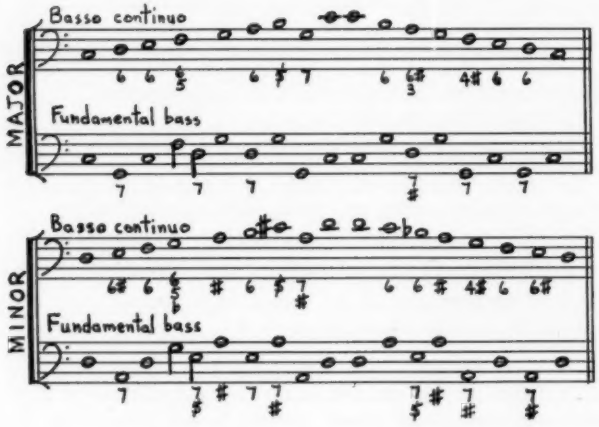
without destroying their proportion!"[36] Rameau has already established this proportion as an arrangement of tones and semitones [T, 23]:

C	D	E	F	G	A	B	C
9:10	8:9	15:16	8:9	9:10	8:9	15:16	

The key (Ton) is thus determined by the name of the tonic note [T, 198], Rameau names the notes of a key: the only ones he distinguishes in the Traité are the tonic, mediant, dominant-tonic, and sensitive note. He refers to the others simply as 2nd, 4th, and 6th notes [T, 199]. All the notes of a key, with the exception of the 6th note, can be found in the tonic and dominant-tonic chords [T, 144].

The same tonic note may bear two modes, which are distinguished as major or minor on the basis of the third of the tonic chord [T, 143, 149]. In the Traité, Rameau confines most of his remarks to the major mode, and he makes rather tentative statements about the minor. He observes that the ascending orders of the two modes are the same except for the major or minor third, but that in the descending order of the minor the sixth and seventh degrees must be lowered in order to maintain a diatonic succession [T, 246].

Rameau follows his predecessors in that he proposes "rules of the octave," or what he considers to be the best harmonizations of the major and minor scales as bass melodies (Ex. 1). The fact that he

Example 1 [T, 382-3].

36. "Elle déterminoit la progression des autres Nottes comprises dans l'étenduë de son Octave....Si nous prenons la Notte ut pour tonique, nous ne pouvons alterer la situation des Nottes ut, ré, mi, fa, sol, la, si par aucun Dieze ni B-mol, sans détruire nôtre proportion [T, 198]."

chooses C on which to demonstrate the major scale and D on which to demonstrate the minor shows that at this point in his thinking he cannot yet apply his one principle to all aspects of music. He does confine the fundamental bass to consonant root movement but is otherwise indiscriminate in his choice of roots (i.e. he uses supertonic chords as well as tonic, dominant, and subdominant chords). One notes in Ex. 1 that the fundamental bass in both modes is the same.

The difficulties encountered in connection with both major and minor modes lead Rameau, in subsequent works, to several very original theoretical concepts. In the Traité he has done little else than observe. The scales he demonstrates are the same ones shown by Zarlino and others; Rameau's single explanation of the perfect cadence is not sufficient for the major mode, no less the minor. Moreover, the descending minor seems to be determined melodically.

In Nouveau Système Rameau tries to apply the principle of resonance to the construction of a key-system. As the arithmetical[37] proportion 1:3:5 produces the most perfect chord, so the geometric proportion 1:3:9 (derived from the first two terms of the former) will produce the most perfect succession of chords [NS, 23]. "So that the fundamental sound may move in either direction without violating the order of the said proportion, we assign it the number 3...(G)...."[38] Thus C equals the fifth below and D the fifth above. The geometric progression therefore "indicates the three fundamental sounds which constitute a mode."[39] Rameau does not attempt to explain why the fundamental sound of the resonant body is the equivalent of the subdominant, not the tonic, root.

Rameau uses the triple proportion to construct a major mode in G [NS, 32]:

G	A	B	C	D	E	F♯	G
24	27	30	32	36	40	45	48

He then relates the minor to this major by the proportion 5:6; the key of this minor is therefore E [NS, 34]:

				C	D		
				128	144		
E	F	G	A	B	C	D	E
80	90	96	108	120	135	150	160

But the three fundamental sounds of the minor mode are not in strict proportion 1:3:9, since E is represented by 80 (the multiple of 40 in the major scale) instead of 81 (which would produce a correct proportion). Rameau cites this fact as another proof of the necessity of temperament [NS, 35]!

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37. Or, more exactly, the inverted harmonic proportion....

38. "Pour que le Son fondamental puisse proceder de tous cotez sans déroger à l'ordre de la proportion proposée, nous luy assignerons le nombre de 3...(Sol)...[NS, 29]."

39. "Indique les trois Sons fondamentaux qui constituent un Mode [NS, iv]."

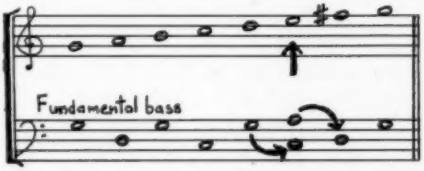
In Generation, Rameau attempts further justifications of his mathematical calculations. In accordance with his mistaken concept of the co-vibration of multiples of a fundamental note, he makes the following chart of fifths [G, 43]:

G^b	D^b	A^b	E^b	B^b	F	C	G	D	A	E	B	F#
729	243	81	27	9	3	1	$\frac{1}{3}$	$\frac{1}{9}$	$\frac{1}{27}$	$\frac{1}{81}$	$\frac{1}{243}$	$\frac{1}{729}$

ARITHMETICAL — HARMONIC PROGRESSION

Any one of these notes may be taken as a fundamental, in which case it will represent the middle term of the proportion 1:3:9 [G, 45].[40] In this case, the middle term 3 represents, not the fifth of the fundamental, but the fundamental itself; 3 is taken to represent unity only to avoid the fractions in the proportion 3:1:1/3. Thus the fundamental sound contains in itself everything which constitutes a mode [G, 64]. The situation of the fundamental remains as the middle term of the triple proportion; the only change since Nouveau Système is this "justification" of the proportion. In order to insure that the middle term be heard as fundamental, the extreme terms should bear dissonances [G, 108]. Since the dominant chord is generated upward from the fundamental, the dissonance is added as a minor third above the perfect chord [G, 111]. Since the subdominant is (supposedly) generated downward from the fundamental, the minor third is added beneath it [G, 111]. This seems to confirm the double-employment theory proposed in Nouveau Système.

Rameau advances a new definition of a mode: it is "the principle which contains in itself the most perfect and natural succession."[41] He no longer contents himself with a major scale constructed from an arbitrary proportion or from an assemblage of notes from the main chords of a key. He now tries to derive a major scale from a fundamental bass in fifths, according to the triple proportion (Ex. 2). This works up to the disputed 6th note, but between the 6th and 7th degrees of the scale, a progression by a second would necessarily occur. Rameau pretends to remove this difficulty by placing a chord of the

Example 2.

40. Although the above chart of fifths is mathematically correct, in the explanation that follows Rameau has again inverted the harmonic proportion.

41. "Le Mode est, en Musique, le principe qui contient en lui la succession la plus parfaite et la plus naturelle... [G, 63]."

added sixth beneath this "6th note," letting the ambiguity of double-employment disguise the imperfection of the fundamental bass [G, 120-30].

In connection with scale derivation, Rameau discusses tetrachords at great lengths. He considers it striking proof of man's instinctiveness for the fundamental bass that the Greeks defined tetrachords without knowing harmony. He goes far afield in this, partly because he shared in the common misconception that these were ascending melodic patterns. The only "positive results" of this study are as follows: the perfect fundamental succession (dominant and tonic) furnishes only one tetrachord: B C D E. But this tetrachord provides

15:16:18:20

Rameau with the diatonic dissonances: the major semitone (15:16), the major tone (8:9), and the minor tone (9:10) successively [G, 58]. Here again Rameau uses an advanced concept to re-define a basic one. This new definition represents the tendency away from the artifice of adding and subtracting intervals [G, 68]. But later attempts to derive a major scale from tetrachords produce very peculiar results.

As regards the minor mode, there is a significant change since Nouveau Système. Rameau now considers the minor to be generated downward from the fundamental as the major was generated upward. This minor is the product of "the arithmetical proportion reduced to its smallest degrees, and subordinated to the harmonic proportion."[42] The smallest proportional degrees Rameau is thus able to obtain are 27:81:243; as in the Nouveau Système, the tonic note is represented by 81, but this time for a different reason [G, 133]. In the ascending form, the dominant should bear a major third only if it moves to the tonic; and the subdominant should be major only in its double employment [G, 134-5]. "In descending, the minor mode comes back into all its rights."[43]

In the Démonstration, Rameau offers even further justifications for the triple proportion. The perfect major chord produces a harmonic proportion, 1:1/3:1/5. The arithmetical proportion 1:3:5 produces a minor chord. The octaves arising from a fundamental are in a geometric series: 1, 1/2, 1/4, etc. Therefore Rameau justifies his application of the geometric series to the other intervals of the perfect chord. This results in the "triple proportion" of fifths (1:1/3:1/9) and in the "quintuple progression" of thirds (1:1/5:1/25) [Dem, viii-ix]. The latter produces the chromatic genre; the former, the diatonic [Dem, 13]. The proportions are themselves limited to three terms, since the addition of a 4th term would result in a dissonance [Dem, xiv].

In the Démonstration, the major mode is given a definition very similar to that of the Generation: it is "the order prescribed among sounds, in harmony as well as in melody, by the triple proportion."[44] But the scale harmonizations, constructed from conjunct and disjunct

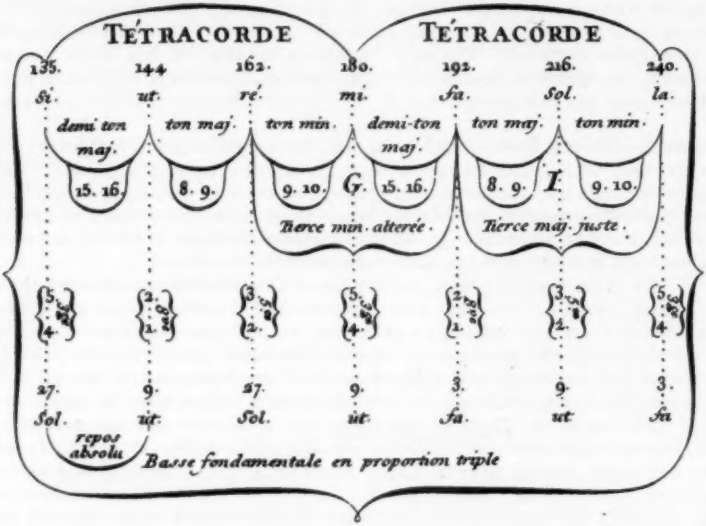
42. "La proportion Arithmétique réduite à ses moindres degrés, et subordonnée à l'Harmonique... [G, 132]."

43. "Ce Mode mineur rentre dans tous ses droits en descendant ... [G, 134-5]."

44. "L'ordre prescrit entre les sons,...tant en harmonie qu'en mélodie, par la proportion triple... [Dem, 34]."

tetrachords, are different from any previous ones. The scale resulting from conjunct tetrachords is shown in Ex. 3. This may obviate the imperfections caused by the three whole-steps in succession, but it causes

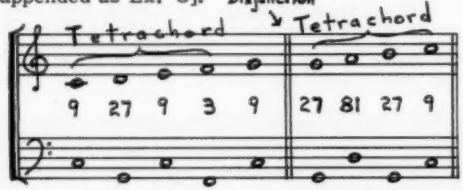
Example 3 [Dem, appended as Ex. B].



even more difficulties. A scale beginning on the leading-tone of a key is unheard of. Moreover, three tones in succession do occur in practice, and Rameau is fully aware of this.

The difficulty caused by the succession of three whole-steps is that, if they are harmonized by the three terms of the triple proportion, the extreme terms will immediately succeed each other, i.e. the root progression of a second will occur. Double-employment was the solution proposed in Generation; at best this implies a 4th term. The new explanation rejects the equivocality of double-employment and assumes a 4th term to the triple proportion (Ex. 4).

Example 4 [Dem, appended as Ex. C].

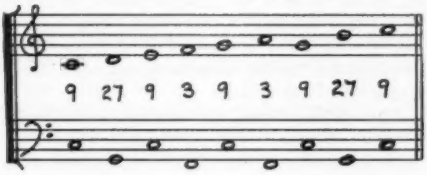


The two tetrachords have the same proportions; but the mode changes. A fundamental bass in fifths is rigidly maintained.

The minor is at first explained rather tenuously. "The principle of C, which in the pure and simple operation of nature produces the major mode, indicates to art at the same time to make a minor on it."[45] As he did the minor chord, Rameau insists that the minor mode should always be considered subordinate to the major [Dem, 29-30]. Further along in the Démonstration Rameau proposes another theory of the minor mode. The minor of C has a new fundamental sound, which "one can temporarily regard as generator of its mode, ... [but which]... is forced to follow the law of the original generator."[46] Rameau hereby rejects even the possibility of an undertone series, and reaffirms his principle that everything in music originates in the resonance of the upper partials of a generator. The major third only is generated directly; a fundamental C generates its major third, E. The temporary generator of the minor, A, does not generate the C, but it is a generator of E. In other words, the original fundamental C gives its major third E to A for a fifth [Dem, 71]. This rather complicated explanation actually represents a return to the point of view expressed in Nouveau Système, where the minor was related to the major by the ratio 5:6 (A:C).

Nouvelles Réflections contains an example of a scale harmonization that is still different from foregoing ones (Ex. 5). Now all the

Example 5 [NR, 19].



roots are in the same mode; they are in relationships of fifths; but the upper line is not a scale!

The latter part of the Code returns to the diatonic system composed of conjunct tetrachords, the same system proposed in the Démonstration [C, 201]. Rameau then states: "in order to arrive at the octave of the middle term... [of the triple proportion]... the Greeks disjoined the two tetrachords; this would necessitate the addition of a 4th term to the proportion."[47] Rameau is thus presenting two imperfect ways of constructing a major diatonic system, instead of trying to limit

45. "Le principe ut, qui, dans la pure et simple opération de la nature, produit immédiatement le Mode / majeure, indique en mêmetems à l'Art le moyen d'en former un mineure [Dem, 62-3]."

46. "Ainsi ce nouveau son fondamental, qu'on peut regarder, pour lors, comme générateur de / son Mode, ne l'est plus que par subordination; il est forcé d'y suivre en tout point, la loi du premier générateur [Dem, 71-2]."

47. "Pour arriver à l'octave du terme moyen, ... les Grecs disjoignirent ces deux Tétracordes: aussi faut-il ajoûter un quatrième terme à la proportion pour cet affet... [C, 201]."

himself to a single imperfect way.

Although he cannot explain it even to his own satisfaction, Rameau is evidently firmly convinced of the validity of a tonal system. Despite a complete lack of scientific evidence of a subdominant, Rameau continues to use the triple proportion to define a key; he stresses that the middle term of the proportion is the principal [C, 208]. Further evidence of this conviction is found in the Code, where Rameau discusses the relationships of keys. Each major key has five other relations: its dominant and subdominant, its relative minor with its own dominant and subdominant [C, 138]. The major key is connected to the dominant chromatically by a sharp and similarly to the subdominant by a flat [C, 138]. It is connected to its relative minor by the tones in common [C, 37].

The explanation of the minor, in the Code, is similar to the one given in the Démonstration: "the two proportions, harmonic and arithmetical, become linked by the same 4th proportional in order to establish a kind of double-employment, which makes the ear choose between two fundamental sounds that can both take the same harmony."[48] Here Rameau mingles several kinds of theories in a desperate attempt to systematize the minor. Despite his rejection of the undertones, he continues to use the arithmetical proportion. Secondly, as he has added a 4th proportional to the geometric series to produce a diatonic scale, so he adds a 4th proportional to the harmonic series to create a chord of the seventh. This chord is a combination of the tonics of a key and its relative minor. Thirdly, as he has used double-employment with reference to the subdominant and "2nd note," here he applies it to the tonic and "6th note."

The difficulties associated with the subdominant and the minor were never resolved by Rameau's successors. Experience convinced Rameau of the validity of the subdominant; experience also demonstrated the ambiguity of the minor, the question of whether a minor or c minor were the true relative of C major. Rameau therefore was impelled to explore the theoretical possibilities of these chords and keys, despite the fact that he could never find satisfactory scientific evidence to explain them.

Rameau mentions a chromatic system, but does not attempt to deal with it as fully as he does the diatonic. Early in the Traité, in connection with the construction of intervals, he proposes a chromatic system [T, 28]:

C	C♯	D	E♭	E	F	F♯	G	G♯	A	B♭	B	C
24:25		25:27		15:16		25:27		15:16		24:25		
	15:16		24:25		24:25		24:25		25:27		15:16	

48. "Les deux proportions, l'harmonique et l'arithmétique, se confondissent avec une même quatrième proportionelle, pour établir un double emploi, qui fait prendre naturellement le change à l'oreille entre deux sons fondamentaux susceptibles de la même harmonie [C, 211]."

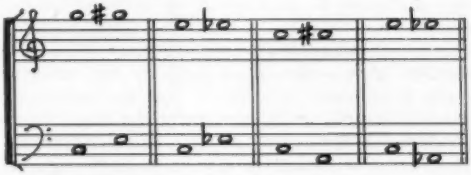
This is in accordance with the diatonic system he has just given and reveals three sizes of semitones, 15:16, 24:25, and 25:27. Rameau does not discuss the use of the chromatic until the latter part of the Traité. It is defined as follows: "In melody, chromaticism consists of a succession which proceeds by semitones, either ascending or descending; this produces a marvelous effect on harmony."[49] These effects can be understood only as a chain of dominants (with each tonic becoming in turn a dominant). The most common usage is therefore in descending [T, 286]; it is also possible in ascending, but this form does not have the sadness of the former [T, 288]. Rameau maintains that chromaticism occurs only in minor keys [T, 286].

In Nouveau Système Rameau attempts to derive a chromatic scale from the minor by placing a major or minor third indifferently upon the fundamental sounds. The result is as follows [NS, 35]:

B C C# D D# E F F# G G# A A# B
480:512:540:576:600:640:675:720:768:800:864:900:960

This results in five kinds of semitones — 15:16, 24:25, 25:27, 128:135, and 135:144! Rameau goes on to demonstrate that the major, minor and chromatic systems are in an order of decreasing perfection. In the partial series, the major system begins at 24; the minor, at 80; and the chromatic, at 480 [NS, 36].

In Generation Rameau tries to relate the chromatic system to a fundamental bass in thirds, as opposed to the diatonic whose fundamental sounds are in fifths (Ex. 6) [G, 145]. The idea of a third is applied also in another connection which has to do with mathematical juggling of intervals. In the diatonic system, the only semitone was the

Example 6 [G, Ex. XlX, referring to p. 146].

major (15:16). The chromatic produces a new interval, the minor semitone (24:25), which Rameau recognizes as the difference between the major and minor thirds. At this point Rameau abandons his former attempts to derive a complete chromatic scale; he confines the function of chromaticism to a change of mode, remarking that the minor semitone occurs only in this connection [G, 148].

Rameau adheres to this point of view in the Code, where he defines chromaticism as a changing of a note into its own sharp or flat.

49. "Dans la Mélodie, le Chromatique consiste en une suite de chant qui procede par semi-Tons, tant en montant qu'en descendant; ce qui produit un effet merveilleux dans l'Harmonie... [T, 286]." Rameau has previously stated that melody has its origin in harmony!

This does not change the third into another interval, it merely changes the genre of third. This chromatic change necessitates a change of key (or mode) [C, 118]. Two kinds of modulations are possible. A note moving "to its own sharp or flat can form successively the minor third and the major third of a tonic";[50] thus it can change the mode without changing the key. It can also change the key completely: "a sharp that ascends almost always becomes a leading-tone, and a flat that descends is most often found in a chain of dominants... [as a seventh]...."[51]

Rameau mentions the word "enharmonic" early in the Traité, in connection with the derivation of intervals [T, 26]. At no point in the book does he deal with enharmonic progressions theoretically. In Nouveau Système Rameau again only mentions enharmonic intervals [NS, 27]. Since enharmonic phenomena are possible only because of temperament, it is necessary to consider Rameau's present views on this. Rameau, as a practicing keyboard performer, is accustomed to temperament. From a theoretical standpoint he demonstrates the "necessity of temperament" because the comma (80:81) is constantly coming up as an error in his calculations [NS, 35]. He discusses temperament for the first time at the end of Nouveau Système; his purpose is to get the keys most frequently used in as good tune as possible. The semitones resulting from this are approximations of either major semitones (15:16) or semitons moyens (125:128) [NS, 111]. This system is called by Shirlaw "unequal or mean-tone temperament [Shirlaw, 137]."

By the time of Generation, Rameau has abandoned this system in favor of equal temperament [G, 96]. He advises musicians to follow his example: "become accustomed to this new temperament; soon you will not even notice things which displease you now."[52] The thirds will suffer more alteration than the fifths, but they are less perfect anyway. Tones and semitones will be even more out of tune, but even musicians have difficulty in distinguishing between the major (8:9) and minor (9:10) tones. Accordingly, it is in the Generation that we find the first description of enharmonic progressions. The enharmonic genre is "a succession of two unrelated keys by the intervention of a new harmony which is common to both."[53] The so-called new harmony is the diminished-7th chord, which occurs in the diatonic system as the leading-tone 7th chord in the minor mode. The lowest note of any inversion may be considered a "sensitive note"; Rameau considers this note both fundamental and derived from the dominant [G, 151]! He mentions two subspecies of enharmonic: "diatonic-enharmonic" and "chromatic-enharmonic." He does not attempt to define or demonstrate these [G, 154-5].

50. "A son dièse ou à son bémol peut former successivement la tierce mineure et la majeure d'une tonique... [C, 66]."

51. "Le dièse où l'on monte devient presque toûjours note sensible, et le bémol où l'on descend se rencontre le plus souvent dans un enchaînement de dominantes... [C, 66]."

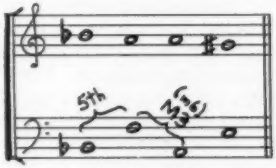
52. "Accoutumez-vous au nouveau Tempéramment, bien-tôt vous n'y sentirez plus rien de tout ce qui peut vous y déplaire à présent... [G, 103]."

53. "Une succession de deux Modes non relatifs par l'entremise d'une nouvelle Harmonie qui leur est commune... [G, 146]."

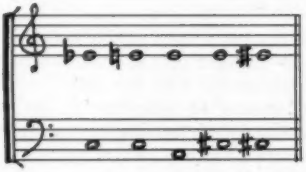
In the Démonstration Rameau makes his definitions somewhat more precise. The diatonic system comes from a fundamental bass in fifths; this produces as its smallest interval the semitone, 15:16. A fundamental bass in thirds produces the chromatic genre, with a semitone of 24:25. The enharmonic genre results from a combination of diatonic and chromatic. Its characteristic is the "enharmonic quartertone" (125:128), which is the difference between 15:16 and 24:25 [Dem, 92]. Rameau claims that this interval is too small to be heard, and of course it is not found on tempered instruments. Nevertheless, he concludes we can feel its effect because of the remote progression of the fundamental bass [Dem, 100-1].

Rameau defines "diatonic-enharmonic" as the result of an "alternate succession of a fifth and a major third."[54] His illustration is given in Ex. 7. "Chromatic-enharmonic" results from a bass descending a

Example 7 [Dem, appended as Ex. M].



minor third, then ascending a major third (Ex. 8) [Dem, 94-5].

Example 8 [Dem, appended as Ex. N].

In the Code, Rameau treats of the enharmonic genre very briefly, stating that it can lead to twelve different keys [C, 68].

Rameau states forcefully that harmony, as the sole basis for music, produces the greatest effect on the listener. Contrasts of range, dynamics, or tempo are only secondary [Obs, vi]. This is Rameau's point of view throughout his writings; as early as 1722 he is expressing affective theories.

In dealing with the affective use of harmonies in the Traité, Rameau uses consonant chords as a point of departure. Consonant chords, according to this theory, can be found everywhere. Usually they predominate in the expression of happiness and magnificence.

54. "Succession alternative d'une quinte et d'une tierce majeure ... [Dem, 93]."

Dissonances may occur in the course of progressions; these should be kept in the inner parts, leaving the outer parts consonant with one another. Sweetness and tenderness are often expressed well by prepared minor dissonances. "Tender complaints" correspond with "borrowed" or "sub-posed" 7th chords, in which there are mostly minor dissonances; major dissonances are best confined to the inner parts. Languishing and suffering are expressed by "borrowed" 7th chords and especially by chromatics. Despair, fury, and astonishment require all sorts of dissonance, especially unprepared, with major dissonances in the uppermost part. Sometimes the key can be changed very rapidly by means of an unprepared major dissonance to heighten these effects. Rameau cautions that dissonance must be used with great discretion; it must be borne in mind that its use must not affect the basic logic of chord progressions. Dissonances may be omitted even from dominant chords if their harshness is undesirable [T, 141-2].

Rameau's treatment of the affective use of keys in the Traité is of a specific nature. "The major mode taken in the octave of the notes;"[55] C, D, or A connotes happiness or rejoicing. F and B^b major are suited to tempests, furies, and the like. G major and E major are equally good for expressing tenderness or gaiety. D major, A major, or E major express also grandeur and magnificence. The minors of d, g, b, or e express sweetness and tenderness; of c or f connote tenderness or plaintiveness; of f or b^b are suitable for lugubrious melodies. "Other keys are not much used."[56] In this connection also he makes a qualifying statement which places the responsibility on the composer's talents: "experience is the surest way to become familiar with the characteristics... [of keys]."[57]

As Rameau himself becomes better acquainted with the nature of keys, he makes much more general statements which show considerable insight into the use of tonal functions. In the Observations Rameau equates joy with the effect of the string divisions (sou-multiples) whose existence is inherent in the resonant body. This is the source of the major third, the major mode, the sharp, the dominant-tonic (fifth above), and the melody which grows stronger as it ascends. For the opposite reason, sadness and regret correspond with the multiples, "whose gloomy silence is disturbed only by their divisions at the unison of the body which caused them to stir, to show that it must represent them."[58] This fact produces the minor third, the minor mode, the flat, the subdominant fifth, and the melody which grows softer as it descends [Obs, 53]. Rameau presses this point further with the statement, "the dominant and the sharp on the one hand and the subdominant with the flat on the other... are... the only means of expressing sentiments or pas-

55. "Le Mode majeur pris dans l'Octave des Nottes... [T, 157]." What a complicated way of saying C major!

56. "Les autres Tons ne sont pas d'un grand usage... [T, 157]."

57. "L'experience est le plus sûr moyen d'en connoître la propriete [T, 157]."

58. "Dont le morne silence n'est réveillé que par des divisions à l'unisson du Corps qui les fait frémir, pour marquer que c'est à lui de les représenter... [Obs, 53]."

sions."[59] Ascending or descending melodic motion can do nothing but confirm (or put in doubt) this kind of expression [Obs, 60].

In the Code, Rameau again refers to the expressive power within a key. In addition to the basic effects of harmony, other effects are possible through the use of dissonances, especially those involving leading-tones. These "accidental sharps, which can produce passing leading-tones[60]," are, for all practical purposes, melodic phenomena. Further expressive power resides in the effect of changing the key. The great art of this is to know how far in the direction of the sharps or flats to modulate analagously to the change of sentiment [C, 170].

Rameau's statement in the Traité that "melody has no less expressive power than harmony"[61] must be considered in relation to his basic premise that melody has its origin in harmony.[62] He makes the assertion that without a good melody "even the most beautiful harmony can sound insipid."[63] After writing page after page about harmony, Rameau is at a loss as regards rules for melody. This realm is left to the genius of the composer.

The only advice Rameau has to offer is in respect to text-setting. The melody should conform to the words in general sense: the final stressed syllable should fall on a down-beat; perfect cadences should be used to terminate a thought and be avoided elsewhere. Recitatives are more difficult than arias, for actual declamation should be imitated. Again Rameau stresses that it is from seeing and hearing operas, not from rules, that the taste for musical expressiveness is acquired [T, 162]. Rameau sums up his theory of affects, and indeed all his theories, very generally: "briefly, the expression of thought, feeling, and passion should be the true purpose of music."[64]

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59. "La Dominante avec le Diéze d'un côté, et la Soudominante avec le Bémol de l'autre...[sont]...les seuls dont / dépende la principale expression en fait de sentimens et de passions...[Obs, 59]."

60. "Les dièses accidentels, qui peuvent former autant de notes sensibles passagères...[C, 170]."

61. "La Mélodie n'a pas moins de force dans les expressions que l'Harmonie...[T, 142]."

62. "C'est à l'Harmonie seulement qu'il appartient de remuer les passions, la Mélodie ne tire sa force que de cette source [Obs, vi]."

63. "Sans lequel la plus belle Harmonie devient quelquefois insipide...[T, 142]."

64. "En un mot, l'expression de la pensée, du sentiment, des passions, doit être le vrai but de la Musique [C, 170]."

Bibliography

C. Code de musique pratique, ou métodes pour apprendre la musique, même à des aveugles, pour former la voix et l'oreille, pour la position de la main avec une méchanique des doigts sur le clavecin et l'orgue, pour l'accompagnement sur tous les instruments qui en sont susceptibles, et pour le prelude: avec de nouvelles réflexions sur le principe sonore. Paris: Imprimerie royale, 1760.

Dem. Démonstration du principe de l'harmonie, servant de base à tout l'art musical théorique et pratique. Paris: Durand, 1750.

Diss. Dissertation sur les différentes métodes d'accompagnement pour le clavecin, ou pour l'orgue; avec le plan d'une nouvelle métode, établie sur une méchanique des doigts, que fournit la succession fondamentale de l'harmonie: et à l'aide de laquelle on peur devenir sçavant compositeur, et habile accompagnateur, même sans sçavoir lire la musique. Paris: Boivin, 1732.

Gen. Generation harmonique, ou Traité de musique theorique et pratique. Paris: Prault, 1737.

NS. Nouveau système de musique theorique, où l'on découvre le principe de toutes les regles necessaires à la pratique, pour servir d'introduction au Traité de l'harmonie. Paris: Ballard, 1726.

N R. Nouvelles réflections de M. Rameau sur la Démonstration du principe de l'harmonie. Paris: Durand, 1752.

Obs. Observations sur notre instinct pour la musique et sur son principe; où les moyens de reconnoître l'un par l'autre, conduisent à pouvoir se rendre raison avec certitude des différens effets de cet art. Paris: Prault, 1754.

Or. Origine des sciences, suivie d'une controverse sur le même sujet. (Bound with the Code, Paris, 1760).

T. Traité de l'harmonie réduite à ses principes naturels. Paris: Ballard, 1722.

Shirlaw, Matthew, The Theory of Harmony. London: Novello and Company [1939].

TOWARDS A NEW CONCEPT OF TONALITY?

by

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This article will present the first, tentative findings in a study of the question: To what extent can the techniques of tonal coherence, as developed in the rich and diverse language of Western music, be applied to certain sonorities and melodic procedures characteristic of the newest music? Since I am primarily concerned with the creative implications of my findings, the results of my explorations are embodied chiefly in a number of compositions which date from 1950. Here, however, I would like to discuss analytically three short examples: an excerpt from the opening of Stravinsky's Le Sacre du Printemps, and two complete pieces from Bartók's Mikrokosmos. Each of these examples illustrates in a striking way the fascinating transformations which triadic principles and techniques may undergo in their non-triadic applications.

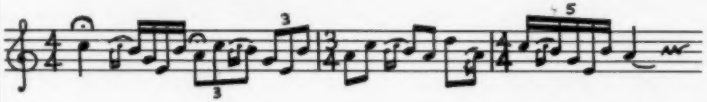
Some years have passed since it was the fashion to regard Le Sacre du Printemps as the embodiment of all that is most radical in musical procedure. Its rhythmic and chordal techniques, so startling in 1913, have become an important part of the vocabulary of many of Stravinsky's younger contemporaries. By now it seems clear that, in this work, Stravinsky has created one of the authentic traditions of 20th-century music. It would follow from both its intrinsic merit and its historical importance that the Sacre is worthy of careful reconsideration on a number of points: To what extent does the work represent a break with the music that precedes it? Does its coherence depend upon techniques found in tonal music? What, precisely, are its innovations? Without in any sense attempting a complete answer, let us consider its opening measures in some detail.

If we listen to the melody alone (Ex. 1, p. 258), it suggests a Russian folk tune. Compare it with the next quotation taken from Mussorgsky's Salambo (Ex. 2, p. 258). Both embellish a descent of a minor third from C down to A via B (upon which the e-minor chord is unfolded). There are further similarities in rhythmic design and in the use of grace-notes. There is also a striking parallel between the dramatic situations depicted, which in both cases are centered around pseudo-exotic "ritual."

In contrast to Stravinsky's setting, Mussorgsky's harmonization of his tune (Ex. 2a, p. 258) fulfills quite simply its triadic implications. There is nothing particularly striking about Stravinsky's melody, as melody, beyond the fact that it has a certain rhythmic suppleness and that it has been assigned to an unusually high register of the bassoon. But the moment we hear the melody within the chordal context Stravinsky has provided for it, it takes on a completely different aspect (Ex. 3, p. 259). For a moment the ear does not know whether to relate the C# or the D of the French horn to the C♮ of the bassoon a seventh above. But with the entrance of the clarinet and bass-clarinet

Example 1.

Stravinsky: Le Sacre du Printemps



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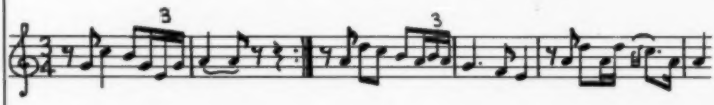
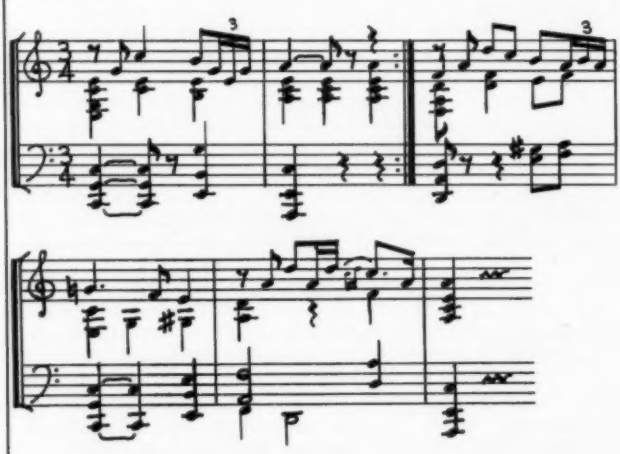
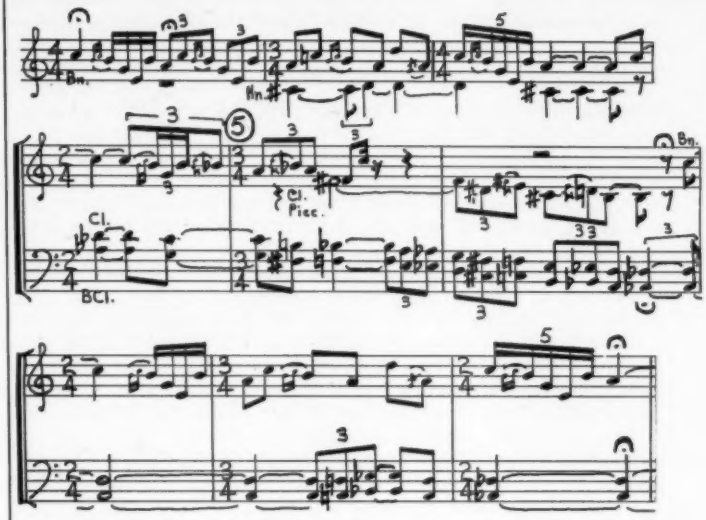
Example 2.

Mussorgsky: Ritual Scene from Salambo*



Example 2a.

*Transposed down one-half step for the purpose of comparison.

Example 3.

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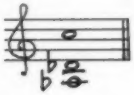
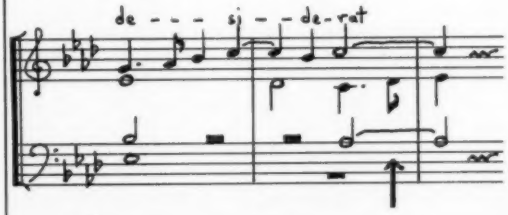
Example 4.



Example 5.

Palestrina: Sicut cervus*

*Transposed up one-half step for the purpose of comparison.

moving chromatically downward in perfect fourths, we begin to sense a characteristic sonority which pervades the little section we are discussing. This sonority (Ex. 4, p. 259) consists of the C of the bassoon melody, the D^b a major seventh below it (first presented by the horn and later by the clarinet), and the A^b of the bass-clarinet, a perfect fourth below the D^b.

If we listen to the passage several times, we begin to realize that this prevailing chord, in this precise spacing, actually serves in the capacity of "tonic sonority" for the passage in the same sense that an a-minor chord, for example, is the "tonic sonority" for a passage in a minor. The difference, of course, is that the a-minor chord, as a consonant triad, is readily acceptable as a tonic sonority, since it has been used as such for several hundred years by composers as divergent in style as Josquin, Bach, Mozart, or Wagner. A dissonant sonority such as that in Ex. 4 would occur rarely, if ever, in the music of the above-mentioned composers, and then never as a tonic, but only as a fleeting accident of voice-leading, where the dissonant relationships would be immediately clarified as passing-tones, neighbor-tones, or suspensions. For example, in the motet Sicut cervus of Palestrina (see HAM I, Ex. 141, p. 153), the sonority of Ex. 4 appears for a moment between the three upper parts on the word "desiderata," as the result of a passing motion in the middle voice as it moves within the A^b-major chord (Ex. 5, p. 259). But the ear is scarcely aware of the sonority as such. Its weak rhythmic position, and above all its subservience to the prevailing A^b-major chord, deny it independent vertical status. It is, as we have said, a fleeting accident of voice-leading.

In what marked contrast it stands to the Stravinsky example! Here the dissonant sonority is so dominant as to take precedence over the triadic implications of the melody. One is "hypnotized" by the vertical sound, which takes on a stable character, and no longer requires resolution. The stabilization of a sensitively spaced dissonant sonority is a technique familiar to us from the music of the impressionists.[1] Nevertheless, the question remains: What are the tonal implications of such a procedure? Is it possible to speak of tonality when the tonic sonority is an unresolved dissonance, however carefully spaced?

The answer, of course, depends upon one's definition of tonality. Few concepts in music are more controversial, yet there seems to be little hesitation in praising or condemning (depending upon one's point of view) much contemporary music as "tonal," or "polytonal," or "atonal," as if, by invoking these terms, one has magically penetrated to the musical essence of a work, often heard only once under the most problematical performance conditions.

For the purposes of this discussion, I would submit the following definition:

1. The 16th-century German composer, Hans Neusiedler, makes use of a similar technique in his singular lute composition, Der Juden Tanz (see HAM I, Ex. 105b, p. 108). There is a clear analogue for the particular stabilized sonority of this dance in the Stravinsky example we are discussing.

TOWARDS A NEW CONCEPT OF TONALITY

Music is tonal when its motion unfolds through time a particular tone, interval, or chord. It is this tone, interval, or chord, called the tonic, which identifies the tonality.

What do we mean when we say that the opening movement of the Eroica Symphony is in E^b major? Certainly we are conveying something more fundamental about it than the fact that it may have a signature of 3 flats, or that its "wandering" middle is sandwiched between E^b-major chords at either end. It would seem, rather, that we are expressing our intuitive conviction that all its details, subsections, and sections, however complex, however seemingly independent, somehow partake of one, single, organic motion through time — a motion which gives scope to, which defines, which is permeated by the "gravitational pull" of E^b from the beginning to the end — in the terminology of our definition, a motion which unfolds through time the E^b-major chord.

It staggers the imagination to attempt to define the precise role of every single note within such a motion. It is hardly more difficult to demonstrate the exact function of every single cell within a living organism. Heinrich Schenker (1868-1935) initiated certain principles and techniques of analysis — still in the process of evolution — which attempted to do just that. Out of his findings developed a graphing technique, which, in a manner far more concise than words, can describe with precision the function of any given tone within that "single, organic motion through time" mentioned in our reference to the Eroica Symphony.

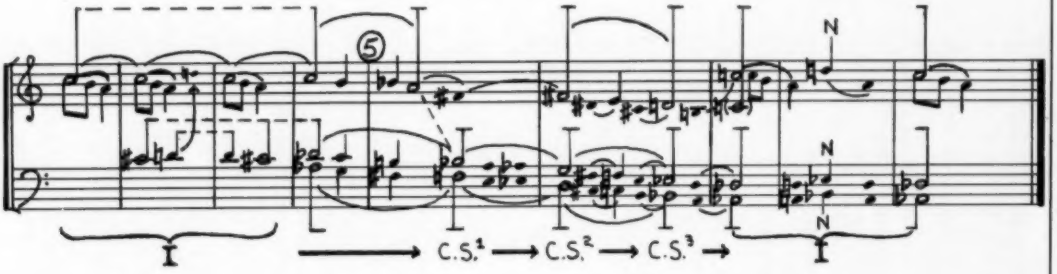
As one listens actively to a given composition, one senses that the various tones fulfill a variety of functions. One speaks of certain tones as "principal"; others are "dependent." Actually, the problem is much more complicated than that. Careful analysis will reveal that certain tones are dependent on others, themselves dependent on others, which, in turn, are dependent on still others! Subject to the length and complexity of the phrase, section, or composition being considered, it may be necessary to establish a hierarchy of a half-dozen or more structural levels in order to describe with precision the role of any given chord or tone within the over-all musical motion.

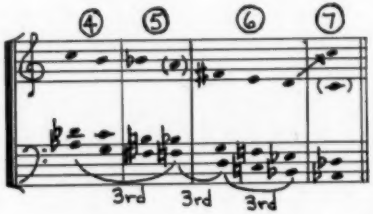
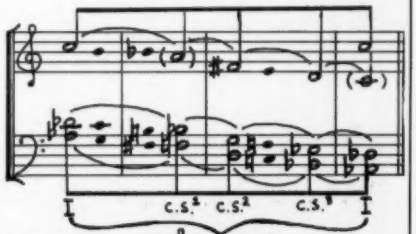
The highest of these levels is called the structure.[2] Those tones which define the basic direction of the top voice make up the top-voice structure. The top-voice structure either circles around one of the tones of the tonic chord, or else it progresses from one chord-tone to another. In triadic music, this usually means a stepwise descent from the third or the fifth into the tonic. Those tones which provide contrapuntal or harmonic support to the top-voice structure constitute the bass structure.

A bass structure is called harmonic if it defines the tonic chord by means of a I-V-I progression, or an elaboration thereof, such as I-II-V-I, I-III-V-I, or I-IV-V-I. It is called contrapuntal if it defines the tonic chord by means of a neighboring, embellishing, or space-filling motion. In any case, whether its top voice circles or progresses, whether its bass is contrapuntal or harmonic, the resultant outer-voice

2. For a fuller explanation of terms and concepts used in the following discussion of tonality, see Felix Salzer's Structural Hearing, (New York: Boni, 1952).

Example 6.



Example 7.

Example 8.

Tonic-sonority defined by means of a contrapuntal structure which fills the space of an octave.

structure is characteristically tonality-defining in function. It presents the primordial tonic triad "in action." In short, the structure is the chief agent for giving final definition to the tonic chord as the musical motion unfolds through time.

That part of the musical motion which vitalizes the bare framework of structure, we call prolongation. It comprises by far the greater and more interesting portion of any given musical motion. The structure is little more than a sterile abstraction unless it can be related, down through all its levels of prolongation, to the "lowliest" detail of the living composition. It is by the beauty and vitality of its detail that we are involved in a piece of music. While there are relatively few possible structures, there seems to be no limit to the number of possible prolongations.

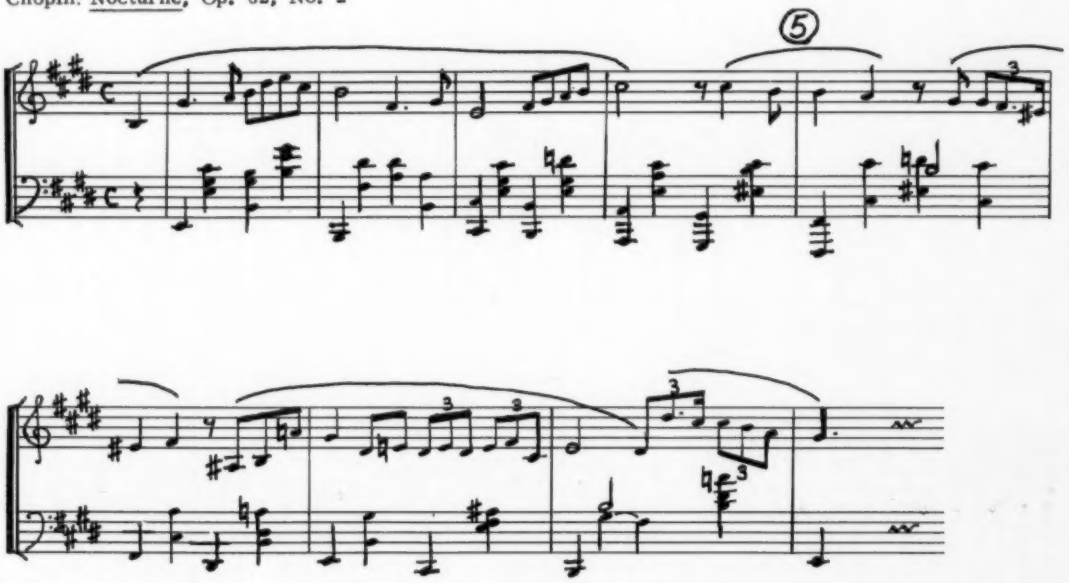
To recapitulate: We have defined as tonal a musical motion which unfolds through time a particular tone, interval, or chord. We have seen that a musical motion does this by means of its structure and prolongations. We then indicated the distinction between these two aspects of musical motion; the structure is the ultimate, tonality-defining progression which is given vital elaboration by its prolongations. Let us now try to answer the question we asked of the opening nine measures of the Sacre: Does the unresolved dissonance of Ex. 4 serve here as the tonic sonority of a tonal music?

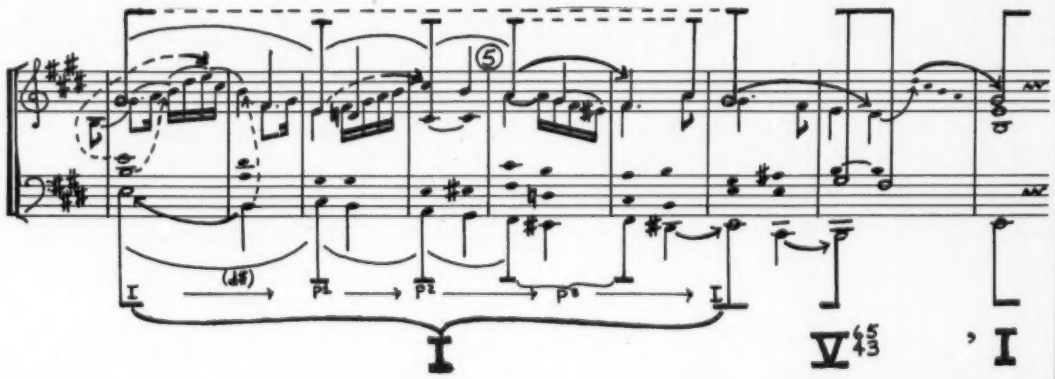
The first difficulty has to do with the chord itself. When a tonality is identified by a major triad, it is possible to trace the relationship of the single tone through the major triad it generates, through the structure which defines the triad, through the various levels of prolongation which elaborate the structure, to the foreground of the living composition in all its richness of detail. In such a case, the tones of the structurally defined tonic-sonority coincide with the first few overtones generated by the root. But this is by no means always the case. Even the innocuous minor triad contains one element, the minor third, which does not exist in the overtone series generated by its root. It follows that the elements of the tonic sonority do not have to be restricted to the overtone series; the historical developments of the past hundred years have shown that chords other than the triad can serve as primordial tonic sonorities. There is no reason why a major or minor triad, a 7th chord, a 4th chord, a polychord, or any other conceivable combination of tones appropriate to the composer's artistic purpose cannot become the tonic sonority of a tonal music. It is only necessary that the combination be capable of definition in terms of structure which is susceptible to vital and expressive prolongation.

Is the chord of Ex. 4 so structured and prolonged? Let us turn again to Ex. 3. The first four measures introduce one by one the three elements of the sonority, beginning with the C of the bassoon, then the D^{b} (or C#) of the horn, to which is added the A^{b} of the bass-clarinet in m. 4. This we have indicated in the first four measures of our analytical diagram (Ex. 6, p. 262).

In mm. 4-6, the clarinet and bass-clarinet, moving in parallel fourths with each other, make a chromatic downward sweep of an octave. The bassoon also begins an embellished chromatic descent from C to A. When it reaches A, it abandons its chromatic motion and leaps ahead into the F# of the entering piccolo-clarinet, which is content to

Chopin: Nocturne, Op. 62, No. 2

Example 9.

Example 10.



wait for the chromatic fourths of its fellow-clarinets to catch up with it at the beginning of m. 6. The piccolo-clarinet then begins a motion in broken thirds, which, fortified by strategically placed grace notes, carries the ear from the initial F#, via E, to D. (The motion A-F# in the bassoon, and the subsequent broken thirds in the piccolo-clarinet, probably have their origin in the opening motive which fills the minor third from C to A.) The piccolo-clarinet is motivically "ready and eager" to go on to C, but this tone has been reserved for the bassoon, which presents it in its original high register. At the beginning of m. 7 it is clear that we have returned to our original tonic sonority.

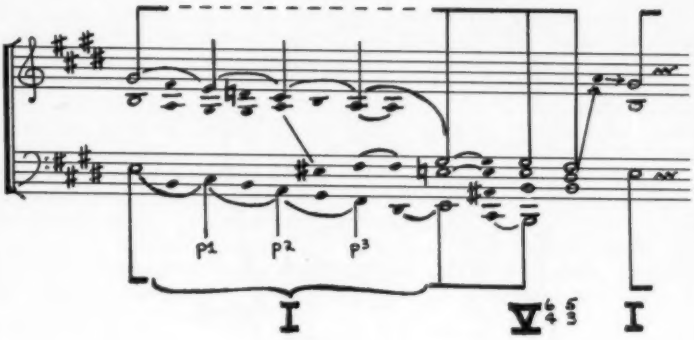
What, precisely, has taken place within these three measures (4-6)? To what extent has the musical motion been conditioned by the tonic sonority? For one thing, it is clear that the characteristic sonority of Ex. 4 has appeared a number of times in exact transposition. In Ex. 7 we have simply listed each of these appearances in order. The A in m. 5 is in parentheses because it has been displaced from its rightful position above (F-B♭) by the impetuous F# it immediately precedes. The register transfer of the final C has been mentioned already. Otherwise, there should be no difficulty in hearing Ex. 7 as the essential progression underlying mm. 4-6. What are the tonal implications of this progression?

It is almost a general principle of musical coherence that those chords which mark the beginning or end of a given procedure of motion tend to serve in a structurally more important capacity than the chords in the midst of that motion. Accordingly, the 1st and 4th chords are structurally more important than the 2nd and 3rd, since the former mark the beginning and end, respectively, of a chromatic motion. We find that this chromatic motion fills in a minor third from A♭ to F♮ in the bass. The precedent set by this filled-in minor third is carried out in two subsequent thirds, from F♮ to D (not filled in), and from D to B♭ (filled in by whole-steps). Finally, there remains one further whole-step, from B♭ to A♭, to complete the motion which has traversed the space of an octave. The resultant octave-filling progression (indicated in half notes in Ex. 8, p. 262) is the structure of the little tonal world we have been considering. As such, it clearly defines the tonic sonority. Thus, mm. 1-9 of Le Sacre du Printemps are in the tonality identified by that sonority.

Are there any precedents for this type of octave-filling motion in triadic music? Let us consider the opening measures of the Chopin Nocturne, Op. 62, No. 2 (Ex. 9, p. 264). The bass moves by means of a deceptive cadence from the E of m. 1 to C# in m. 3. From C# it passes, by means of applied dominants, to A in m. 4 and to F# in m. 5. This F# is prolonged through the first half of m. 6, proceeding via D# to the E at the beginning of m. 7. There is a clear analogy between the resultant octave-filling motion (E-C#-A-F#-E) and the bass-motion which underlies the Stravinsky example (A♭-F-D-B♭-A♭).

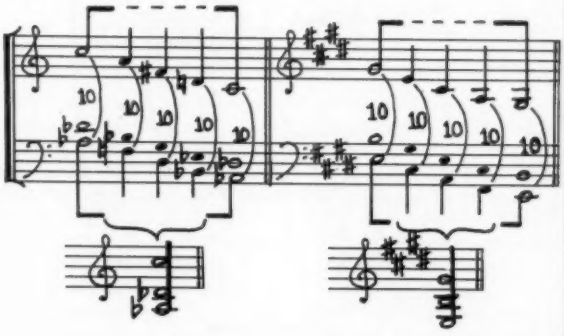
The top voice of the Chopin example makes expressive use of a number of techniques of melodic prolongation (Ex. 10, p. 265): in mm. 1-2 and 8, inner voices are shifted to the top; in mm. 3-4, there is a transfer of register; in mm. 5-6 and 7-8, there are motions into an inner voice of the f#-minor and B-major chords, respectively. In its underlying motion, however (G#-E-C#-A-G#), the top voice parallels

Example 11.



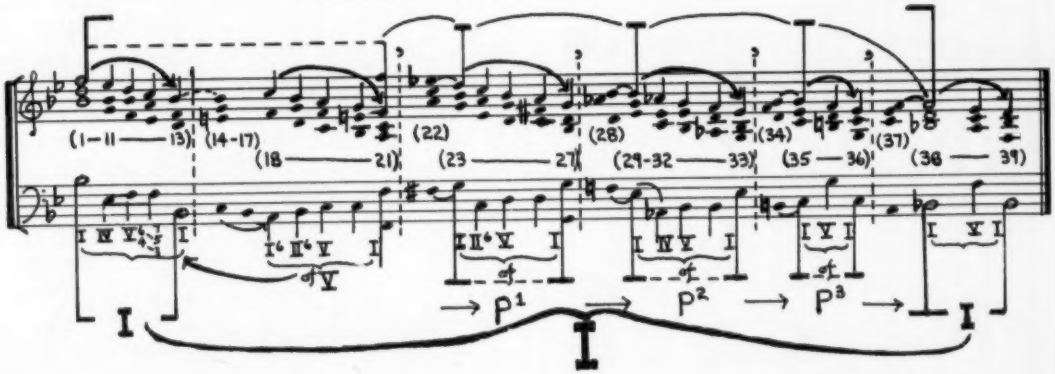
a) Stravinsky b) Chopin

Example 12.



Mozart: Trio (No. 19) from The Magic Flute

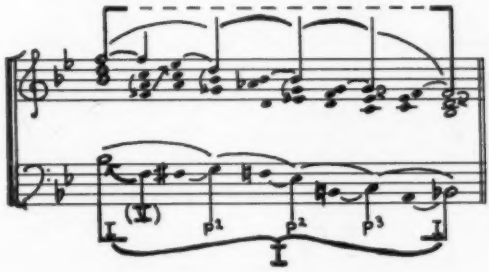
Example 13.



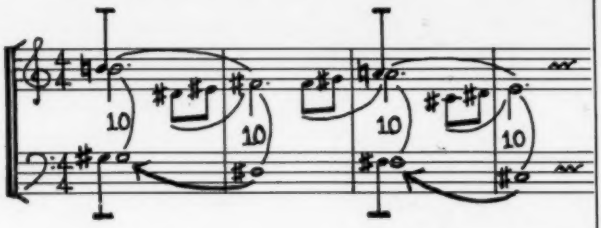
the bass in tenths, as in the Stravinsky example (Ex. 12, p. 267).

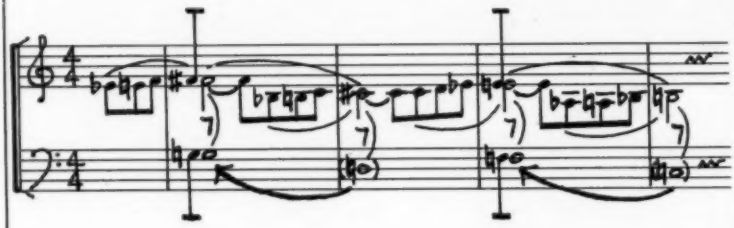
The octave-filling motion in the Stravinsky example is structural for its context; there are no other bass-tones of greater or equal structural significance within the measures considered. The octave-filling motion in the Chopin example is prolonging – it prolongs the tonic triad for 6 1/2 measures. Thus the Chopin example relies on a more inclusive and characteristically harmonic I-V-I progression for its structure (Exx. 10 and 11). Nevertheless, whether it is structural or prolonging for its respective context, the octave-filling motion is clearly chord-defining in both cases (Ex. 12).

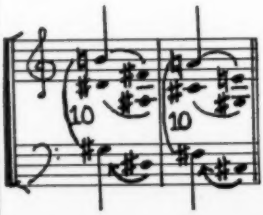
One could cite a number of other such instances: In his B♭-major trio from The Magic Flute (where Pamina and Tamino bid each other reluctant farewell at Sarastro's gentle urging), Mozart has used a similar octave-filling motion as the basis for a series of "modulations" spanning almost forty measures! The resultant "plan" is briefly summarized in Ex. 13 (p. 268). Note how each of the three passing-chords (on G, E♭, and C) is articulated by its own harmonic progression which supports a melodic descent into the inner voice of that chord. If we eliminate these prolonging progressions, the analogy to the Stravinsky and Chopin examples becomes completely obvious (Ex. 14).

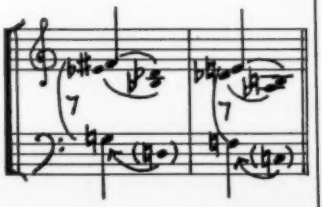
Example 14.

(Unfortunately, limitations of space make it impossible for me to include a graph more detailed than Ex. 13, showing the relation of the foreground of this fascinating piece, in all its richness of dramatic characterization, to the underlying motion here indicated.) Mozart has used this identical "modulation plan" on at least one other occasion in the last movement of his piano sonata, K. 333, mm. 56-97. (In Ex. 335 of Structural Hearing, Salzer has shown that an ascending variant [C-E♭-G-B♭-C] of this octave-filling motion forms the basis of an exciting phrase from Weber's overture to Der Freischütz.)

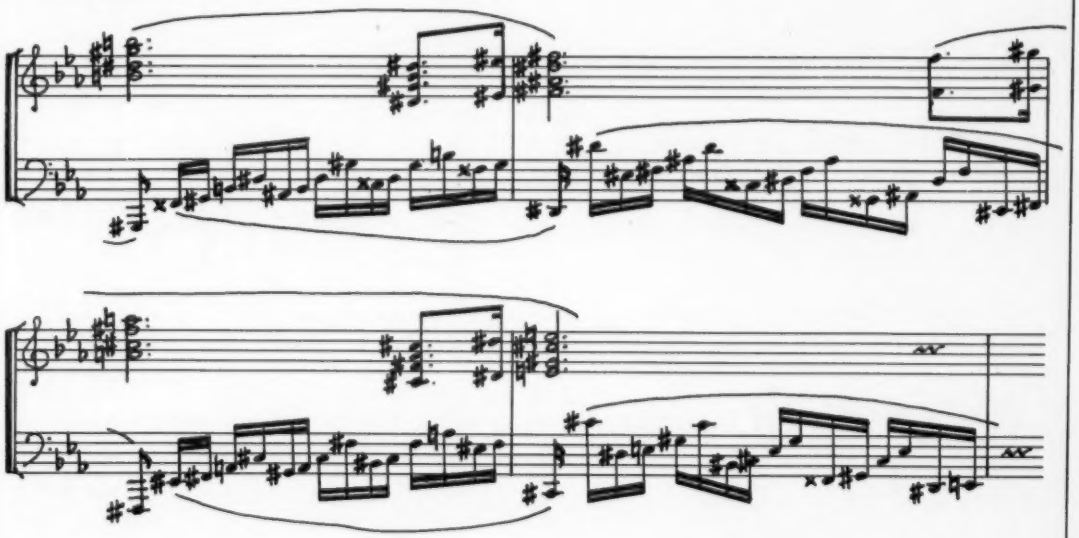
Thus it would appear that one of the most important innovations of the opening nine measures of Le Sacre consists in the application (conscious or unconscious) of a triadic technique of tonal coherence to a particular dissonant sonority. Have other dissonant sonorities been similarly treated? Consider a sequential technique for moving downward by whole steps (Ex. 15, p. 270). If one wished to employ such a triadal device in terms of a dissonant sonority like that of Ex. 16 (p. 270), where the major seventh is the characteristic outer-voice

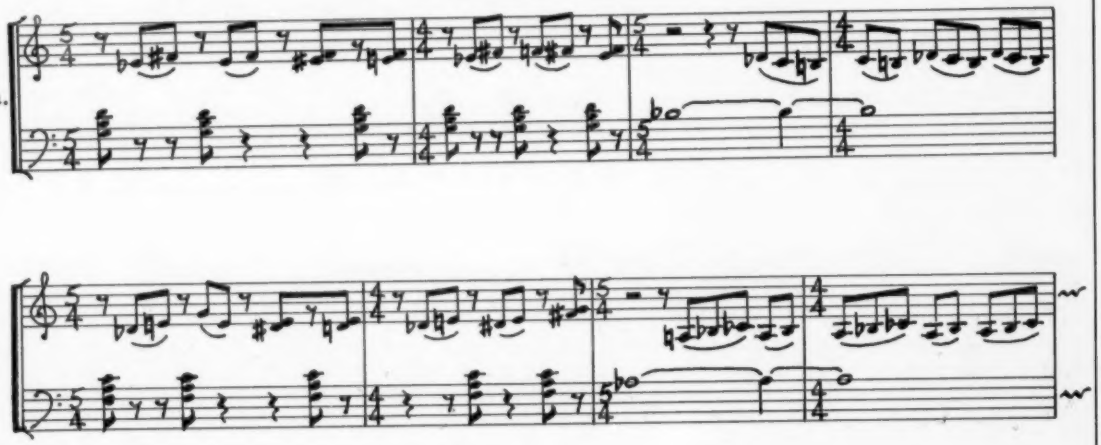
Example 15.

Example 16.

Example 17.

Example 18.

a) Chopin

becomes

b) Bartok

Chopin: Etude, Op. 10, No. 12

Example 15a.

Bartok: "Syncopation" (No. 133) from the Mikrokosmos

Example 17a.

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interval, the result might be something like Ex. 17. That this could bring about a more than casual stylistic transformation can be seen by comparing Ex. 15a (p. 271) (from the Chopin Etude, Op. 10, No. 12) to Ex. 17a (p. 272) (from No. 133 of the Mikrokosmos of Bartók). The analogy between the two implicit chord progressions seems quite clear (Ex. 18, p. 270).

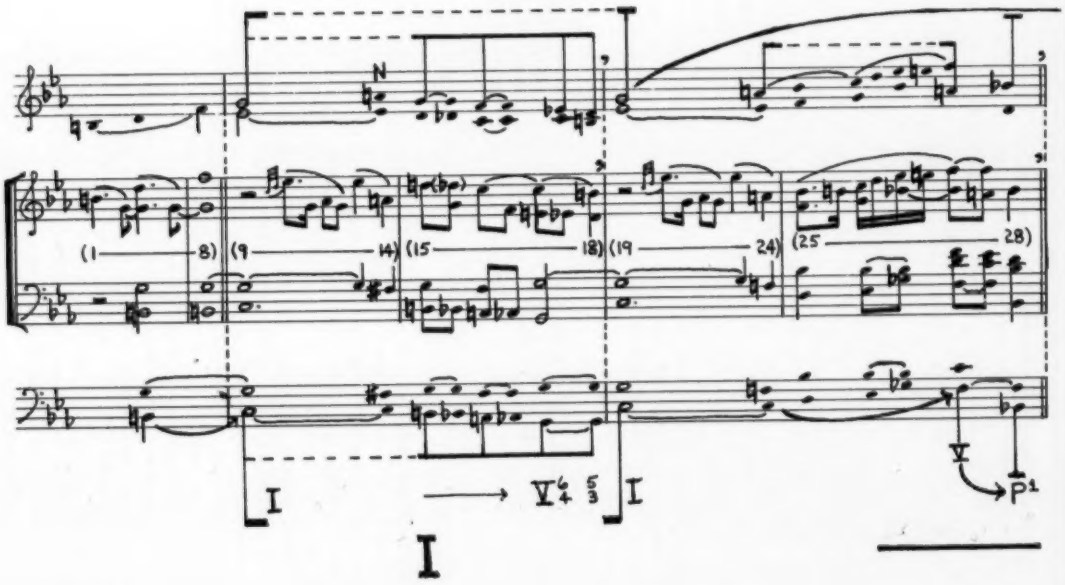
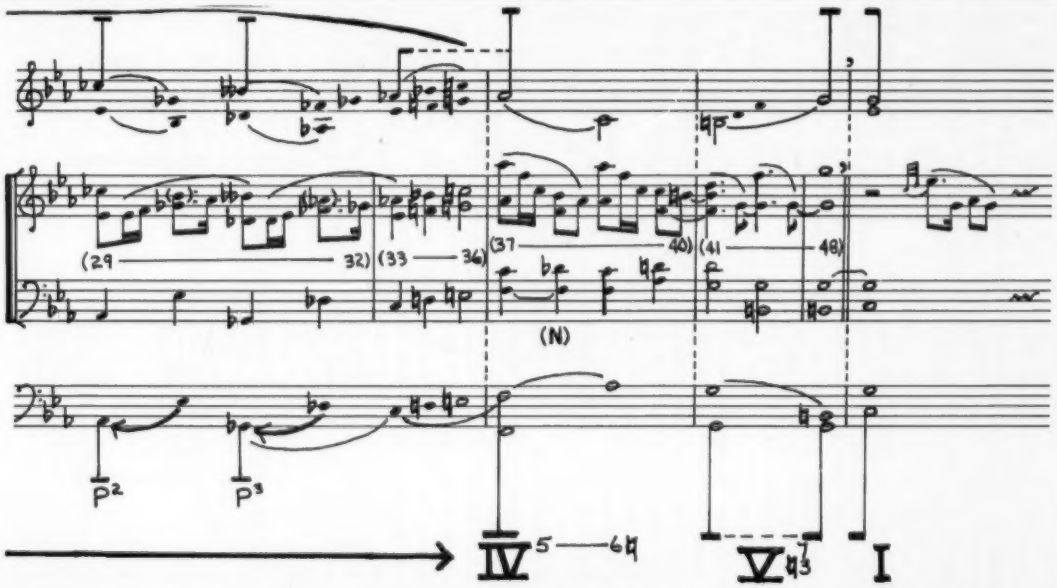
Both these quotations are fragmentary. In Ex. 19 (pp. 274-5) we have placed the Chopin excerpt into its original context in order to show the meaning (for the tonality of c minor) of the descent from the g#-minor chord of m. 29 to the f#-minor chord of m. 31. We find that it is part of a more inclusive passing-motion in the bass, from the tonic C of m. 19, via B^b, A^b (G#), G^b (F#), to the F of the climactic subdominant chord reached at m. 37. It is of special interest that the minor second, from G^b down to F, has itself been further prolonged by means of an inversion of the interval to a subdivided major seventh, from G^b up to F (Ex. 20). Thus we see that the chromatic middle section of this etude is primarily concerned with a passing motion from the I-chord to the IV-chord within the I-IV-V-I progression which is structural for mm. 1-49.

Example 20.

But what is the meaning of the descending progression in the Bartók example?

Let us suppose that we wished to create a harmonic structure for the sonority of Ex. 16. As we have already observed, the major seventh is one of the characteristic intervals of this sonority (just as the major or minor third is one of the characteristic intervals of the triad). If we wished to give expression to this characteristic interval in the structure, it is conceivable that we would arrive at the progression shown in Ex. 21 (p. 277) in which the outer voices move in parallel major sevenths with each other. At first hearing, this material seems anything but promising. Surprisingly, it is not so much the dissonance which is disturbing, but the disjunct upper parts. While we can accept the leaps in the bass because of their clear harmonic function, the leaps in the top voice seem unconvincing. Perhaps we can justify them in the prolongations. First let us subdivide the downward leap of a fifth, from I to IV into two thirds: G to E^b, and E^b to C (Ex. 22, p. 277); then let us diatonically fill in the first of these thirds (Ex. 23, p. 277); next, let us fill in the leap from V to I with chromatic, contrary motion (Ex. 24, p. 277). If we wished to extend our working space, we might place the IV-chord an octave higher, using A to subdivide the resultant sixth in the bass from E^b up to C, and using G to subdivide the seventh from C down to D (Ex. 25, p. 277). If we compare the results with Ex. 21, we find that we have prolonged the "way" from each structural chord to the next; furthermore, this has resulted in a pleasing variety of registration.

Since it is the presence of E^b and F# which distinguishes our tonic sonority from an ordinary G-major chord, let us rely on these two

Example 19:*



*Tones on the outer staves are meant to suggest structural values; those on the inner are an approximate reduction of the underlying rhythmic organization of the etude at a scale of quarter-note equals one measure. It is hoped that the resultant "proportional-rhythm graph" will prove helpful in keeping the reader oriented.

tones as our chief motivic source (Ex. 26, pp. 278-9). In effect we have arrived at a "proportional rhythm graph" for No. 133 of the Mikrokosmos. We do not mean to imply that Bartók followed any such thought process in composing this piece. A principle of tonal coherence is none the less operative because it was employed unconsciously.

Note that in Exx. 21-25 the two upper voices to the V-chord have always been A♯ and C♯. In Ex. 25 these two tones are anticipated in the immediately preceding chord (the chord whose bass [G] had the function of subdividing the seventh from IV down to V). It is now apparent that an additional transfer of register has been introduced at this stage of prolongation. The bass (D) of the V-chord is now transposed two octaves higher (!) into the treble-clef (m. 18). Rather than have the upper voices (A♯ and C♯) sound below this "stratospheric" bass-tone, Bartok has eliminated these tones altogether. The result is a striking and climactic unison which is the sole representative of the original V-chord. It is in sharp contrast to the prevailing congestion of sonority. Surely this is a stroke of genius; in a highly dissonant context, what can be more strident than a unison!

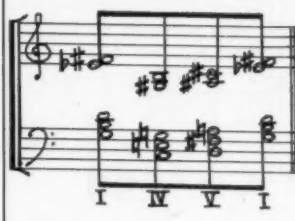
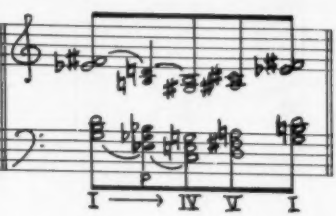
Note how the chromatic contrary motion, introduced in Ex. 24, has been transformed. The right-hand makes its ascent to the top voice (F♯) of the tonic sonority by "growing" a chromatic chord cluster; the left-hand, in the meantime, busily traverses what has now become a perfect twelfth, instead of the original perfect fifth from V down to I. The abandonment of the chromatic chord-cluster technique at the moment of arrival on F♯ in the top voice, and the subsequent reiteration of the original tonic sonority, illustrate convincingly the extent to which the V-I progression has been intimately and organically permeated by the unique prevailing sonority of this composition.

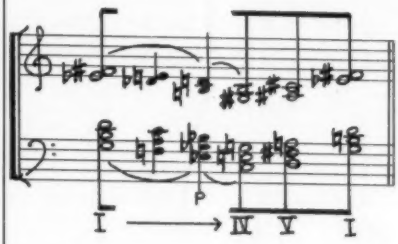
Now if we compare the I-chord reached at m. 25 with the original tonic sonority of m. 1, we see that a few more inner voices have been "thrown in," possibly to compensate for the thinner sonority resulting from the greater distance between the two hands (Ex. 27). (We suspect that the F♮ is not a bona fide chordal element but was introduced to prepare for the embellishing bass-motion [E-F-F♯-G] of m. 27.) In

Example 27.

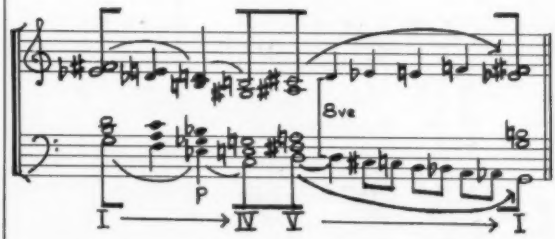
becomes

any case, the I-chord now has such a wealth of tones that, in order to prolong it harmonically, Bartók has only to move his bass-voice (m. 31). The final four measures of this piece present a tonic pedal in the bass, supporting a top voice which ascends through the chordal interval F♯-A♯. In principle, the resultant "motion within a chord" is not unlike the quotation from a Bach prelude given in Ex. 28, p. 280. Here there is also a tonic pedal in the bass, supporting a top voice which ascends

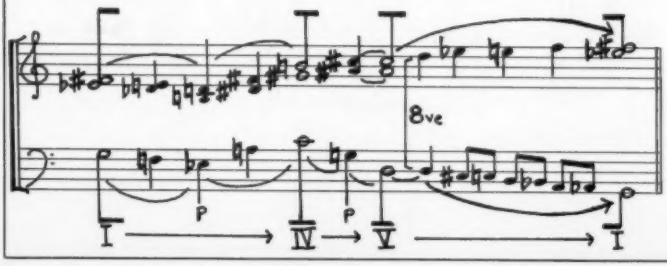
Example 21.

Example 22.

Example 23.

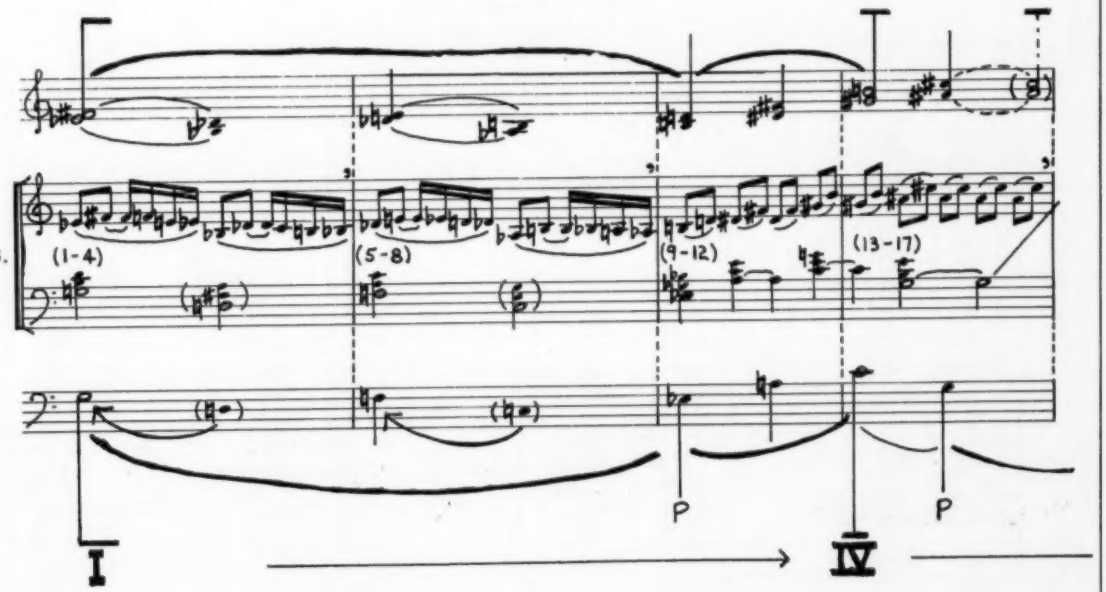
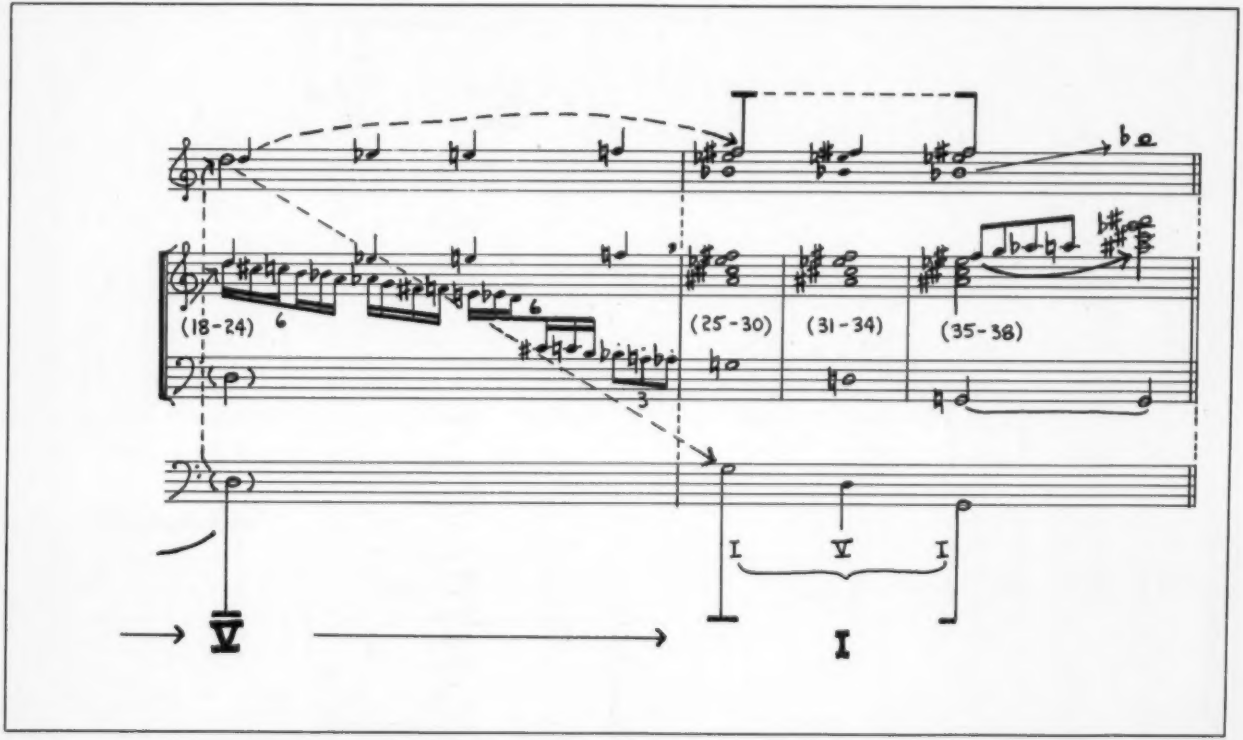


Example 24.

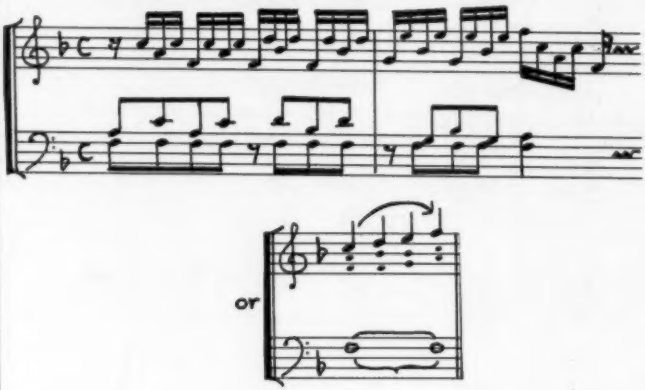


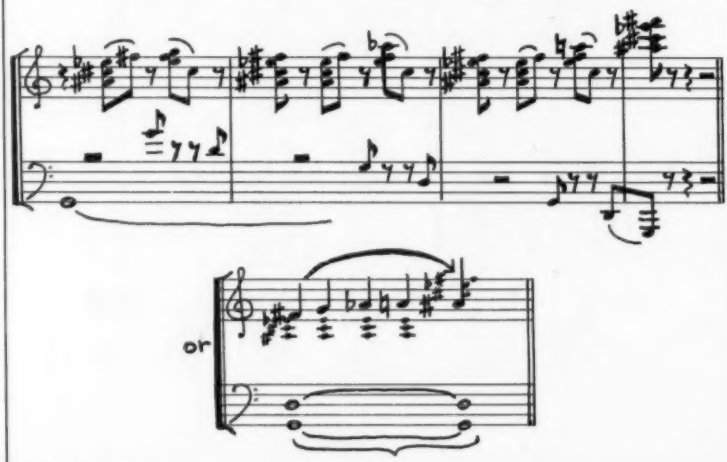
Example 25.



Example 26. Bartok: "Syncopation" (No. 133) from the Mikrokosmos


(18-24)
(25-30)
(31-34)
(35-38)
I
V
I
V
I

Example 28a.

Bach: Little Prelude in F Major

Example 28b.

Bartok: "Syncopation" (No. 133) from the Mikrokosmos

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through a chordal interval C-F (see Salzer, Ex. 170).

In spite of enormous stylistic differences, it is now apparent that the Chopin Etude Op. 10, No. 12 and the Bartók piece have much more in common than the sequential device which we used as the pretext for this discussion (Exx. 15 and 17). Both compositions rely on the same harmonic progression (I-IV-V-I) for their structure. Furthermore, the descending sequential technique serves in both cases to prolong the "way" from the I-chord down to the IV-chord. In a paraphrase of Mark Twain's response to his premature obituary, we can only say that reports of the death of the tonic-dominant system are greatly exaggerated.

For our final example we should like to discuss a piece which does seem completely devoid of harmonic influence. Nevertheless, it presents features of directed motion which fully qualify it as "tonal" within the terms of our definition. Like "Syncopation," "Staccato," No. 124 (Ex. 29, p. 282-3) is also from Vol. V of the Mikrokosmos.

In this piece Bartók seems to be concerned primarily with setting up a polarity between the tones A and E^b. In so far as its "motion unfolds through time a particular interval" (the tritone), this music would be tonal, in accordance with our definition ("music is tonal when its motion unfolds through time a particular tone, interval, or chord").

Although it is "through-composed," the piece falls into three main subsections: an A-section, mm. 1-10; a B-section, mm. 11-29; and a C-section, from m. 30 to the end. (In numbering measures we did not include the half measure up-beat to m. 1.) The first of these sections has the task of prolonging the tonic interval by moving out of the bass E^b chromatically down to the top-voice A. The change of register indispensable to this process takes place in m. 3.

The B-section has the task of moving from the original form of the interval (E^b-A) of mm. 8-10 to the inverted form (A-D#) at m. 30. This motion is prolonged by means of a passing chord which subdivides the space of the tritone into two minor thirds in both voices; thus, the bass moves E^b-F#-A, while the top voice moves A-C-D#.

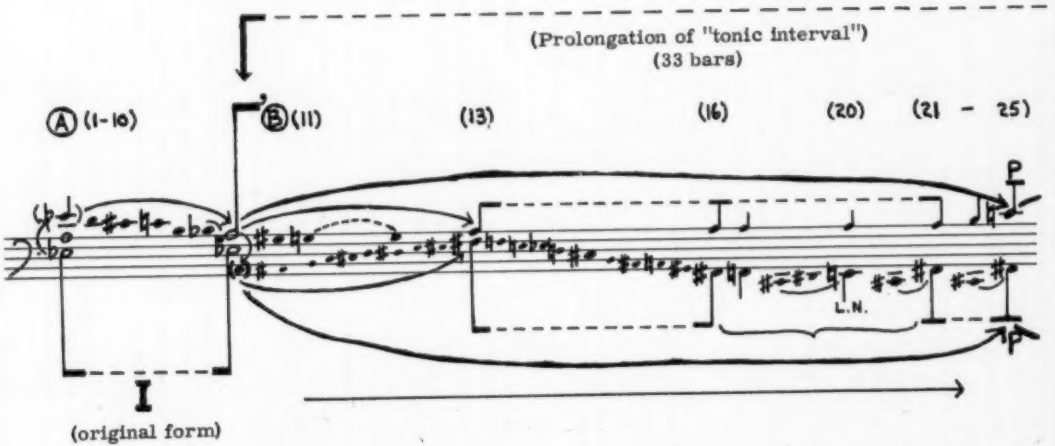
The C-section has a double task. First, it moves from the inverted form of the "tonic interval" reached at m. 30 back to the original form reached at m. 34. Note how Bartók has won a sonorous four-voice texture from his meager "tonic interval" by holding the original form of the tritone in the inner parts while the outer parts converge upon it (mm. 32-33). The other task of the C-section is to make the structural ascent. It does this by moving from the bass tone D# (E^b) via five contrapuntal-structural (C.S.) intervals, to the unison which ends the piece. (In his prolongation of the fixed top voice [A] of this oblique motion, Bartók uses an "accelerating" upper-neighbor motive in three different registers. Thus it happens that the final unison has become an octave.)

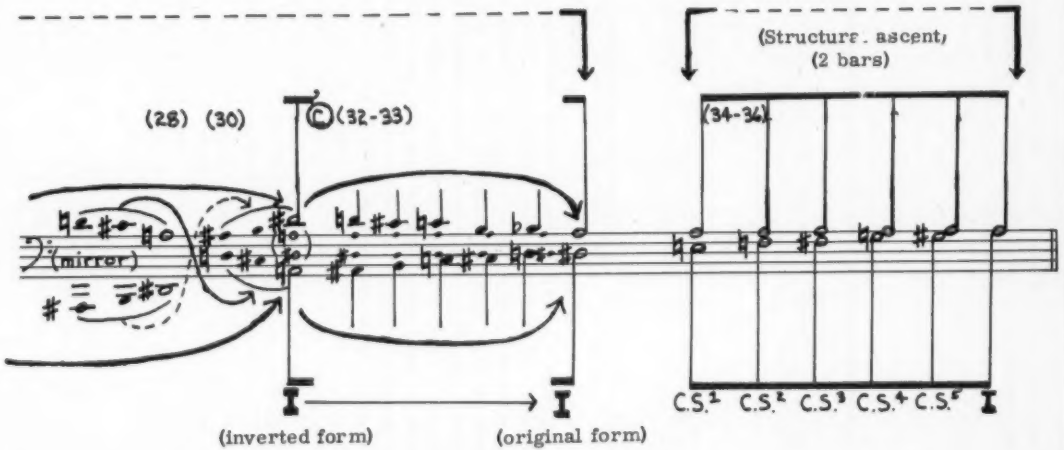
As in many triadic compositions, by far the greater portion of time is filled by the prolongation of the tonic. The structural denouement is withheld until the last three measures (Ex. 30, p. 284). In this respect, music often shows its close kinship to another time-art, the drama.

Whereas a composer like Bach or Mozart felt free to draw upon a vast arsenal of techniques found in the works of a hundred other composers, the 20th-century composer has often felt compelled to forge

Example 29.

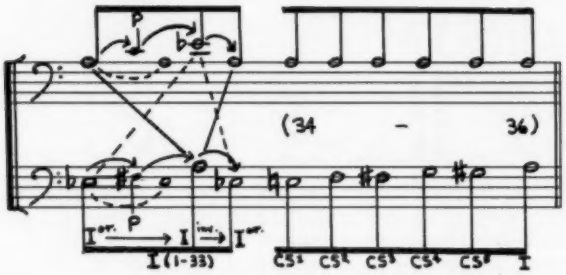
Bartok: "Staccato" (No. 124) from the Mikrokosmos




(Structure ascent)
(2 bars)
(28) (30)
(32-33)
(34-36)
(mirrer)
C.S.¹ C.S.² C.S.³ C.S.⁴ C.S.⁵ I
I
I
(inverted form)
(original form)

from chaos the very elements of his craft. It is therefore interesting to speculate on the extent to which either Bartók or Stravinsky made conscious use of the principles of tonal coherence which apparently underly these three examples. It is highly improbable that either of

Example 30.



these composers arrived at his results by blind instinct. It is even more improbable that either deliberately devised a "tonic sonority," sought a "structure" to define it, then explored possibilities for "prolonging" that structure (although this might prove to be a useful compositional exercise). One suspects, rather, that a composition grows out of its details — but the process of creation is indescribably complex. By whatever means new tonal systems may be achieved in the future, one thing is certain: they will remain sterile abstractions until the enchantment of artistry illumines them with human meaning.

THEORY FORUM

RE: THE PROPER NATURE OF A COURSE IN HARMONY

By James Bakst

The many varieties of modern musical practice and the resulting plethora of styles have caused the teaching of harmony to slip its moorings and become a perplexing array of different presentations and methods. An examination of musical curricula in institutions of higher education reveals a diversity of approaches to a basic course in harmony. Courses in harmony are labeled traditional, conservative, classical, diatonic, chromatic, formal, practical, elementary, keyboard, instrumental, and finally, just plain harmony. The result is often confusion in the minds of teachers and students. Teachers realize that the concepts of harmony as a science represent essentials that are independent of the place and time they are studied. The difficulty is to convince students of the value of these essentials in the fulfillment of contemporary musical purposes. Students in harmony courses often doubt the advisability and practicality of studying triadic harmony and rules of voice-leading in the face of contemporary harmonic practices. They learn harmonic rules in the classroom and see the annihilation of these rules in the works of modern composers. A skeptical attitude often results. Students often question the logic of harmonic restraints; they would like to compose harmony and, invariably, they like what they compose — to the utter chagrin of the teacher whose opinion is resented by students.

The problem is to evaluate the nature and function of harmony, to formulate a logical curriculum, and to place a course in harmony in its proper perspective as knowledge, tool, practice, and a training medium in the curriculum of a music student. An analysis and evaluation of harmony may very well lead to the formulation of a course that will be simple and practical, presenting harmony, not as a tonal medium that is fixed and unchangeable, but as a course that achieves the status of educational necessity in the musical curriculum.

We shall address ourselves in turn to the following aspects of the problem: (1) harmony and musical forms; (2) the theory of harmony as an abstraction; (3) harmony, musical logic, and the essential problem of the teaching of harmony; (4) extension of the principle of harmonic abstraction into aspects of tonal media in general; and (5) the logical curriculum for a course in harmony.

Music as an art is the unity of subjective and objective aspects, that is, the unity of tonal media, purpose, idea, expression, and method. Form in any art represents imagery and associational aspects by means and media pertaining to the specific art. A musical composition is musical form. Every musical form is the embodiment of ideational-emotional content by expressive means typical of national or racial cultural values during an historical era. This form is unique, that is, individual, and incapable of being duplicated or repeated. There are as many musical forms as there are compositions. From a theoretical

point of view, form can be described as a contour or outline of tonal elements. This contour is realized by composers as an individual manifestation of musical form. This realization consists of a specific internal organization of tonal media as an embodiment of the composer's idea, purpose, and method.

Harmony is essential to musical form. The continuous harmonic succession, or flow, does not submit itself to prescribed formulas of chord progressions. It reveals itself as a continuous series of different, individual, unique appearances of musical form. Harmony per se is an objective factor in musical composition that becomes a carrier and embodiment of the idea or purpose; that is, its qualities, manifestations, arrangements, and classifications are considered in themselves, without reference to music as an expression of idea, symbol, or purpose. Aesthetically, harmonic architectonic becomes an embodiment of the ideational content and of musical imagery. The richer the ideational content of a composition, the more interesting its form, and the more individual its harmonic structure. For example, the ideational content of Shakespeare's Romeo and Juliet is harmonically revealed differently by Berlioz, Gounod, Tchaikowsky, and Prokofieff. Each of these composers tried to reveal truthfully the content of the drama through appropriate harmonic factors in individual musical forms.

The theory of harmony is an abstraction. Harmony per se is a product of musical thinking and logic. In The Beautiful in Music Hanslick states[1] that "music has no prototype in nature." Whether or not one believes that triads and seventh chords exist in nature, the fact is that harmony, as a science, is a logical means of musical thinking. It could be added that the techniques and color combinations of great painters, the equivalent of harmony in visual arts, hardly exist in nature. There is no impressionistic pointillism of Seurat in nature; the same could be said about the color schemes of Van Gogh. The truth is that the logic of harmonic thinking is inevitably the result of natural acoustical laws. The triad is the first independent harmonic unit formed by the partial tones, in ascending order and graded loudness in relation to the fundamental tone.

The organized unity of musical form includes the concept of musical genres, that is, various manifestations of musical styles. A musical genre represents different types of compositions related by content and specific musical expression evolved during a cultural-historical era. The dances of the baroque suite are characteristic musical genres representing a specific historical-cultural reality. The symphonies of Haydn and Mozart are genres evolved under the influence of social-musical requirements. The songs of Schubert are musical genres of early Romanticism. The symphonies of Beethoven, from the Eroica to the Ninth, are manifold musical genres whose ideational content defies imagination. Impressionistic tendencies are musical genres of form and content. Wagner's music dramas are genres homologous with Western culture in the nineteenth century. Genre is the key to the

1. Eduard Hanslick. The Beautiful in Music, translated from German by Gustav Cohen, edited by Morris Weitz (New York: Liberal Arts Press, 1957), p. 50.

understanding of musical metamorphoses embodying the perceptive imagination of a composer. There is, generally, little distinction in substance between program music and absolute music. Words are powerless, and often meaningless, in describing the content of an instrumental composition.

The above observations enhance the argument that the harmonic structure of a musical composition represents adaptations of the theory of harmony as an abstraction to the needs of a composer. The theory of harmony makes possible a classification of chords, and it clarifies certain norms concerning the movement from chord to chord. Most of the laws in the theory of harmony can be deduced from the natural phenomenon of the overtone series. There are no specific laws or formulas of harmony established by Beethoven, Chopin, Liszt, Wagner, Brahms, or Tchaikowsky. Their harmonic structures represent adaptations of abstract harmonies to expressions of emotional-associative factors characteristic of their individual styles. In a similar sense, Bach's Well-Tempered Clavichord is not an example of musical abstractions of technical sound-forms. The preludes and fugues represent the achievement of Bach in expressing and embodying emotional-associative factors characteristic of the baroque era.

It is a well-known fact that Chopin was influenced by the heroic imagery of the Polish poet Mickiewicz. In an article describing his meeting with Chopin, Schumann quotes Chopin to the effect that the ballades in g-minor and F-major were inspired by the poetry of Mickiewicz. Attempts have been made to connect the A-flat-major Ballade to Heine's Lorelei. Whatever the pros and cons, there is no doubt that the ballades represent a marvelous adaptation of harmony as an abstract science to Chopin's imaginative representations. The manuscript of Chopin's G-minor Nocturne, Op. 15, bore the inscription "after the presentation of Hamlet." Chopin then crossed out the inscription and added: "let them guess it!" The earliest biographers of Chopin pointed out that the Impromptu in F-sharp Major represents the following picture: a young Polish mother bends over the crib of her child and sings a lullaby; the mother falls asleep and dreams of a magic chorus that foretells the future of her child, who will grow up to be a courageous fighter for his country. When one hears the composition, the opening is indeed a lullaby; then follows a choral part, an heroic march, and then indefinite reveries. The reference to one of the greatest musical romantics is appropriate. The harmonies of Chopin are abstractions and technical sound-forms. They serve as carriers of the associative-imaginative content in the musical composition, an objective tool for Chopin's musical thinking.

By contrast, classical composers such as Haydn and Mozart, with their realistic thinking lean towards harmonic concreteness which verges almost on objectivity in the use of elements of harmony. Painting by means of harmonies, that is, representation of imagery by means of sounds, is only of some importance in their styles. Let us recall the attempt to describe lightning by means of sounds in Haydn's Creation. Aesthetically this lightning is feasible only because, during a storm, sharp, strident sounds are possible. The use of abstract chord-structures for tone-painting is conditional in Haydn's Creation because of faulty associations. The "aria of jealousy" in the fourth act of Mozart's Marriage of Figaro where Figaro sings "husbands open your

eyes" is a good example of the use of chords, which in themselves are abstract harmonies, for psychological effects: the flitting melodies and harmonies in the orchestra seem to paint visions of inconstant, deceitful women in Figaro's imagination.

The adaptability of harmony as an abstract science to various aspects discussed can be explained in terms of psychology; hearing is used mainly to apprehend time; the aptitude of hearing to analyze time and tone-qualities in music is based not so much on the properties of hearing as such, as on the character and associations of our mental imagery, and also on aspects of existence of sounds in general in the surrounding immediate reality of our existence.

Musical logic is an abstract process. For example, the sonata-form is aesthetically a logical reflection of dramatic, associational, and imaginative processes of reality. The recapitulation is not a musical device, but a necessity, an abstraction of an associational order. As a design, the sonata-form is an abstraction based on elements of contrast and repetition. The logic of the science of harmony as an abstraction coincides with the science of logic, that is, validity in thought. There is nothing musical in the science of logic. The science of harmony is an abstraction, not a musical expression[2] Musical thinking, as musical logic, guides the composer's idea. This musical thinking, employing the science of harmony as an abstraction, helps a composer to express an idea or purpose.

The foundations of musical thinking emerge with the organization of definite tone-successions, scales, which make possible the construction of musical forms. Acoustical laws are the foundation of musical scales. The organization of a scale enables music to avoid the disorganization or irregularity of tonal manifestations and allows the development of musical expression from very simple to very complex conceptions. The order of abstract scale-patterns does not nullify the expressive content of music. It actually unifies musical content and subordinates it to the logic of thinking processes. Aesthetically, abstract musical logic is the reflection of musical objectifications of successions of harmonies in tonal formations. The science of harmony is an abstraction of human thinking in general taking place in the realm of music. In dealing with the diatonic scale-system we have tonal series of stable and unstable intervals and chord-functions around a tonic. These series represent musical logic in the shape of patterns of chords, not something peculiar to the inner qualities or character of tones.

A question arises as to why a problem of teaching harmony exists. The answer is that the logical method to teach a course in harmony is not as the practice of harmony, that is, composition, but as the theory of harmony whose laws are deduced from the natural phenomenon of the overtone series. In the former method we are dealing with composition; that is, musical form, and harmony as a manifestation of musical thinking and imagination. This mixes up the science of harmony and musical expression, an impossible problem for a student and unnecessary in a course in harmony. The introduction of a compositional basis

2. The word "expression" is used here in a very broad sense, from the imitation of speech intonations to the most complex imaginative-associative patterns of mental imagery.

into the teaching of harmony invariably involves the problem of the inner conflict between musical expression and musical thinking. Neither the teacher nor the student can solve this. It leads to confusion in the student's grasp of connections of chords. In the latter method, teaching harmony as a theory based on acoustical laws, students learn principles of chord-connections and procedures as musical grammar. This is the essential problem in the teaching of harmony.

Aesthetically, musical expression seeks to subordinate musical logic; conversely, musical logic tries to subordinate expression. In composition the science of harmony as an abstraction controls musical expression. The apparent struggle reaches a balanced solution in the emergence of logical musical expression and imaginatively enriched patterns of harmony. This has been achieved by the great masters of music. To teach this in a harmony course is impossible and unrealistic. It belongs to the domain of musical composition.

The concept of abstractiveness is not peculiar to harmony alone. It belongs to other elements of tonal media, such as rhythm, meter, melody, dynamics, etc. Inasmuch as these elements are always associated with harmony, the theory of harmony as an abstract science becomes the logical basis for a foundation course in harmony.

Rhythm is the qualitative aspect of music. It is the succession of equal and unequal pulsations. From the point of view of expression, rhythm represents momentary manifestations of melodic, harmonic, and polyphonic expressive values. From the abstract point of view, rhythm represents momentary manifestations of melodic, harmonic, and polyphonic logic. For example, the functional aspect of a chord might change on different beats of a measure. The effect of a tonic $\frac{6}{4}$-chord on a weak pulsation is different from the effect of the chord on a strong pulsation. Changes in rhythm affect the functional aspects of chords. Harmony, melody, and polyphony are inconceivable without rhythm. Music could not exist without rhythm as an expressive value and as an abstraction. For example, the effect of the scherzos in Beethoven's Seventh and Ninth Symphonies depends on the unity of expressive and abstract rhythms: rhythm as an expressive-intensity value is supported by rhythm as abstract logical-rhythmical figures, rhythmical periods, enhancing the logic of the musical form as a whole.

Meter is the quantitative aspect of music. It would be a mistake to regard meter as a purely mechanistic aspect. Meter is the logical ordering of rhythmical manifestations. For example, a 6/8 measure can be varied rhythmically. Despite this rhythmical variety, all 6/8 measures in a composition have a common rhythmical foundation in the guise of a steady metrical pattern. The characteristic of rhythm as an expressive value is freedom in the time-successions of pulsations. This is especially notable in rubato tempos and in music of a recitative character. This freedom is practically non-existent in march and dance music. Rhythm as abstraction constantly gravitates to measures, in other words, clearly defined metrical patterns, and periodicity of 2, 4, or 8 bars in sentences or phrases. This phrase-sentence rhythmical periodicity is a logical, abstract manifestation, not a rhythmical expressive value. It is excellently demonstrated by the logic of cadences and cadential aspects in general.

Musical dynamics and tempo also reveal a duality of expression

and abstraction. Gradations in volume, changes in tempo, are not only determined by expressive factors, but also by musical logic and abstract functions of design. This is demonstrated in classical and romantic cadential aspects where the tonic is subjected by logical requirements to manifestations of dynamics and tempo by means of fortissimo and ritenuto.

The duality of expressive and abstract factors is always present in melodies written in the major and minor scales. Aesthetically, a melody in music reveals expressive factors, intervallic relationships, of the human voice. Of course the human voice, intonation, reveals the utmost variety of intervallic relationships. This freedom cannot be realized in melodies because the acoustical logic of scale-construction shuns chaotic intervallic relationships of the human voice. Thus, while the intonational qualities of the human voice lose their freedom in melodies, the melodies find compensation for the loss of this freedom in the abstraction of scale-construction. The stability and instability of intervallic relationships within a scale controls expressive factors in a melody. Modulations are the logical means to enhance tension factors. Certain tones and figures within a melodic contour can become points of stability and instability, gradations of anticipations and consummations, thereby revealing melody as an aspect of musical logic. Analysis of melodies in classical and romantic music will reveal the above aspects. Melodies often combine recitative (expression) and singing-arioso (abstraction) features. This is evident in the melodies of late Beethoven. In Chopin's nocturnes, recitative elements are followed by instrumental melodic characteristics represented by abstract melodic configurations.

In romantic music abstract aspects of melodies assume symbolic significance. An example of this is the opening theme in Liszt's Faust Symphony: the augmented chord is the musical imagery of Faustian doubts and indecisions. The whole-tone scale of the impressionists might be considered in terms of abstractions. The essence of musical impressionism is the subordination of associative-imaginative elements.

The principle of abstraction and logic underlies the polyphony of a fugue and of all imitative devices. Aesthetically, the abstract logic of polyphony bears a comparative resemblance to aspects of baroque culture and world-feeling.

The most successful classical and romantic composers were those which were able to employ the abstract logic of the science of harmony for the enhancement of imaginative-associative elements in music. Conversely, the composers who failed in the above attempts produced harmonic structures consisting of trite cadences, formulas, and specific abstractions of harmonies.

Harmonic theory as an abstraction gives us the foundation of musical symbolism. The peculiar cadences in the first presentation of the theme in the introduction of Richard Strauss' Don Quixote represent symbolically the strange, false thoughts of the hero. The conclusion of Thus Spake Zarathustra is another example of the use of abstract chords for musical symbolism: the riddle of the world that Zarathustra could not solve. Similar examples are in the Alpine Symphony: patterns of abstract chords in the shape of wandering modulations and chromatic changes are examples of conditional musical-harmonic logic

used symbolically.

Finally, is not the science of orchestration an abstraction? The principles of the contrast of timbres, of orchestral groups, of individual instruments — are not these principles abstractions, orchestral logic used for purposes of expression? Just as it is possible to have an unbalanced relationship between expression and the science of harmony, it is possible to have the technique of orchestration outweigh aspects of expression. Berlioz' style is an adequate example of this.

The logical, abstract function of harmony and the teaching of harmonic theory as an abstraction is supported by historical facts. The human ear has reconciled itself to the apparent falseness of the tempered scale for the sake of logical and abstract reasons (freedom of scale-patterns and modulational patterns), not for reasons of expression. This substantiates the conception that the theory of harmony is an abstraction and the teaching of harmony is of necessity a logical process of simple chord connections.

As a science, harmony considers chords in themselves, without reference to musical form as an embodiment of ideational-emotional content. The concepts of this science are essentials independent of place and time they are studied. They represent musical grammar that students should understand and command. The teaching of harmony should be separated from elements of musical composition.

We can now formulate the curriculum of a harmony course based on the ideas discussed. Such a course will dispense with individual expressive-interpretative criteria which are based on compositional considerations. They confuse students.

The course should deal only with fundamental laws of harmony, that is, the theory of harmony (principles and norms) not the practice of harmony, composition. There should be no formulas and laws of chord-progressions which students are required to memorize and duplicate. The human voice naturally guides chord progressions according to the ease with which they can be sung. A chord thereby assumes functional values, that is, the connections of the voices are determined by what precedes and follows a chord.

Acoustical laws revealed in scale-construction are fundamental truths that underlie chord-progressions. The practice of harmony is a practical adaptation of chord-formations in compositional aspects. The injection of creative elements into the course will require constant explanations, justifications, and deviations from adherence to theoretic norms, the essential musical grammar, which students are supposed to learn and master. The practice of harmony has its function in musical analysis where it rightly calls for imagination, receptivity, and understanding of expressive values in musical forms, and the amalgamation of expression and chord abstractions.

The question of where such a course fits in an age of modern harmonic diversities is irrelevant. Any music student must have this foundation, the essentials of literacy in the science of harmony, in order to understand advanced harmonic manifestations.

The melodic materials (bass, soprano) to be harmonized should adhere to utmost simplicity, with a preponderance of scale-patterns. Simple melodies give students greater scope in voice-connections. Moreover, as the class progresses, exemplification of the principles

learned can be demonstrated from the works of the masters in whose style such simple melodic patterns abound.

The following topics will form the content of the course: (1) chord-structure and progression; (2) the major and minor modes including inversions, sevenths chords, secondary dominants, diminished triads, and chord of the added sixth; (3) ninth, eleventh, and thirteenth chords; (4) altered chords; (5) modulations; (6) figured basses; and (7) elementary analysis of simple chorales and free settings.

An average class can easily cover the material in two terms and gain a good mastery of the discipline. This is possible because the course will avoid speculations and polemics. After a short time of close application and concentration the student will master the subject.

Artificial rigidity which often plagues the study of harmony actually hinders intelligence in students' action and volition. The ideas presented here, based on natural unencumbered voice-connections of chords, embody fundamentals proper to a required course in harmony. The essentials of harmonic knowledge are necessary tools to bridge the gap leading to the understanding of music and its processes. It is harmonic knowledge put to work, not merely worship of this knowledge for its own sake. It substitutes first-hand harmonic experience for rigidity and unrealistic practices. A harmonic curriculum planned in advance and circumscribed with esoteric examples, artificial musts and don'ts, unrealistic formulas is a course of study that may inhibit students' interest. A constructive harmonic curriculum represents what students draw from their own practices. They will realize that the great masters of music set up no laws, or formulas; that the way to learn harmony is for students to draw from their own practices the experience to achieve their purposes in solving harmonic problems. This is a course in harmony in action.

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RE: HARMONIC PROCEDURE IN THE FOURTH QUARTET OF BELA BARTÓK

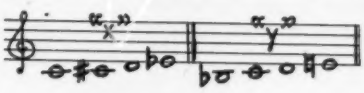
By Leo Treitler

It is the purpose of this paper to present some observations about the ways in which the music of this quartet is located around specific pitch-areas, and about the relationships that are imposed upon the pitch-groups which assume this central role.

The significance of the tone C as a landmark for the quartet has been repeatedly pointed out.[3] I should like first of all to amend this to "C-in-conjunction-with-E," at least as regards some of the critical structural fulcra: the opening two notes of Movement I, before the commencement of the chromatics; the range C-E of the viola's ostinato beginning at m. 14 of Movement I; the range C-E of the chord on beat 2 of m. 26, Movement I; the range C-E of the cadential chord in the final measure of Movement I (the E^b and D^b are appoggiature); the C-E in m. 54 of Movement III, upon which this movement converges as a point

3. See Matyas Seiber, The String Quartets of Bela Bartók, (London: Boosey and Hawkes).

Example 1.



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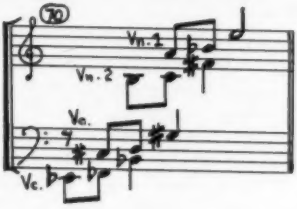
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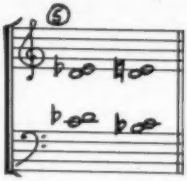

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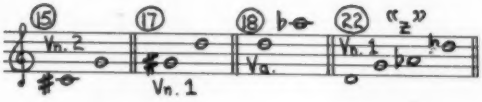

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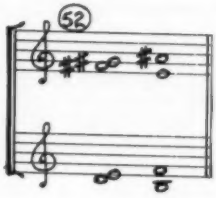
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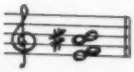


of repose; and the C-E range of the final measure of the piece. I shall have more to say about the reasons for considering the C and E together at the conclusion of this discussion.

But one thing must be kept entirely clear: this C, or C-E, is in no sense a tonality. It is an arbitrarily chosen, static "tonal center" which is not involved in any scheme for generating secondary tonal areas. The only implication it has, beyond this role of a static point of reference, lies in the possibility that the ear may refer sections of the quartet which deal largely with thirds and related intervals back to this prominent third.

There is, in fact, a dual approach to harmonic organization in this work. One aspect is this maintaining of a pitch or pitches as a reference; the other is a scheme which will be the subject of the remainder of this discussion.

George Perle[4] has demonstrated the use in Movement I of two basic four-tone "sets" which he labels "x" and "y" (Ex. 1, p. 292). They can readily be seen to be at work in all five movements. Both sets are used linearly to provide melody, and vertically as chords. Further, they regulate contrapuntal activity, in that canonic imitation often occurs at the intervals of a particular set so that the set can be followed diagonally across the score (Ex. 2). Finally, by being maintained at specific pitch locations, the sets can be made to act as harmonic poles. For example, the material from m. 6 through beat 2 of m. 26 (Movement I) seems to gravitate toward the tritone B^{b}-E, outlining the y-group in its initial locus. That is to say, while other tone-complexes are heard together with this locus of the y-group, it is the latter which repeatedly returns unchanged, and which is further marked for the ear's attention by means of rhythm, dynamics, pitch-range, and textural distinctions.

A harmonic relationship between the two sets is defined at the outset and maintained throughout. The x-group characteristically expands to the y as shown in Ex. 3. Upon hearing the first, we normally expect the second to follow. This expectation has important consequences for the harmonic events of the quartet.

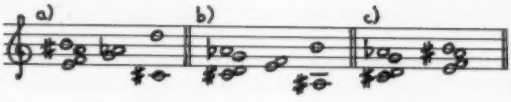
A third group emerges from melodic material in the second subject of Movement I, beginning at m. 15. Here the second violin has the range C#-G, which is imitated by the first violin at m. 17, a perfect fifth above, G#-D, and finally by the viola at m. 18, with a range that is the inversion of the latter, D-A^{b}. All this is summarized, or telescoped, in the first violin at m. 22 with the notes D-G-A^{b}-D^{b}. This is the first unambiguous appearance of the group I shall call "z". Its emergence is shown in Ex. 4. The z-group is related to the y as the latter is to the x; i.e., the y expands to the z, first at m. 52 and frequently thereafter (Ex. 5). The z-group has equal importance in the form shown in Ex. 5 and in that resulting from an inversion of the outer seventh, i.e. the fifth enclosing the fourth (Ex. 6). Exx. 4 and 5 show the z-group at two different pitch-locations, as it appears in m. 22 and m. 52, respectively, of Movement I. An investigation of certain intervallic properties of this group will show the relationship of these loci.

In the inverted form shown in Ex. 6, the z-group may be con-

4. "Symmetrical Formations in the String Quartets of Bela Bartók," Music Review, XVI (1955), 300-12.

Example 7.

Example 8.



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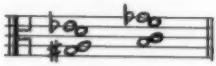

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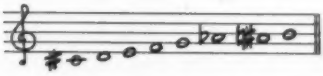

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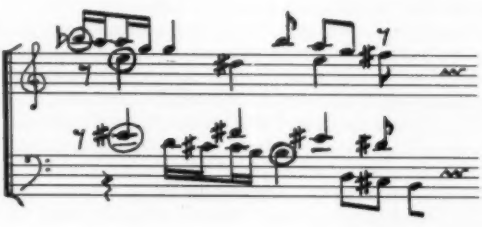
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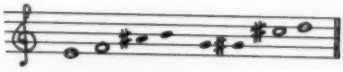
sidered a combination of two chromatic diads which bear to one another the following relationship: considering either diad as a center and moving outward an equal number of degrees in both directions (the distance of a tritone) we arrive at an inversion of the other diad. Continuing the movement through another tritone, we return to the initial diad, separated by two octaves (Ex. 7, p. 294).

The four-tone structure as a whole is symmetrical about the diad G-A^{b}. Proceeding as in Ex. 7, now with G-A^{b} as a center, we arrive at the new diad C#-D (Ex. 8a). This gives a second pair of diads with the same mutual relationship as the original pair. This second structure is, again, symmetrical about the diad E-F with which we began (Ex. 8b).

What results is a pair of four-tone groups (Ex. 8c) which bear to one another a relationship somewhat analagous to triads related by fifths: both constitute systems in which movement from one chord to another is regulated by an interval basic to the structure of the chords. There is this difference: In the case of triads the movement I-V, if continued, produces II, VI, etc., requiring traversal through the entire circle of fifths before a return to the point of origin is effected. V-I involves reversal of the initial motion. In the present case, because the regulating interval is the tritone, continuation and reversal are equivalent processes; the circuit is closed with two chords.

It will have been noticed that the two positions of the z-group related as in Ex. 8c) are precisely those heard in mm. 22 and 52 of Movement I (Exx. 4 and 5). The significance of this fact for the formal structure of the movement will be touched on below.

A most direct application of this relationship is found in No. 109 (Volume IV) of the Mikrokosmos, "From the Island of Bali." This piece depends entirely upon the simultaneous use and later alternation of the groups shown in Ex. 9. They constitute a pair such as is described above. (The mention of this piece is not meant to imply a Balinese origin for these harmonies; in fact the title puts one somewhat in mind of Mozart's "Turkish" music.)

To complete our view of this scheme, we must consider the eight notes of the two overlapping groups in ascending order. They constitute a scale of alternating half-steps and whole-steps (Ex. 10). It can be no coincidence that this scale is played literally for three octaves by the viola at the conclusion of Movement II, accompanied by a cello arpeggio from the same scale. Nor is it a coincidence that the scale serves as a source for melodic material; the most obvious case is the main tune of the final movement. There the connection between the scale and the z-group becomes explicit, when, at mm. 32-33, the first violin and cello play the latter outright.

The scale is a familiar Bartók sound; it can be recognized, for example, in the Out of Doors Suite, the Suite, Op. 14, the Piano Sonata, and the Cantata Profana.

Reference to a few places in the quartet will illustrate the application of these relationships.

In Movement I the tritone B^{b}-E, outlining the y-group in its initial locus, is maintained as a harmonic reference throughout much of the exposition (which ends at m. 49). But beginning at m. 37 it acquires an association with, and gradually gives way to, an x-group, C#-D-D#-E, which is the only remaining sound in mm. 47-49. This x-group, which

is already a half-step higher than the initial x-locus, is not permitted to expand to y as expected before it slides up another half-step (m. 49 and the first beat of m. 50). The y reached after this delay — C-D-E-F# (second beat of m. 50) — must now slide up a whole-step (m. 51, D-E-F#-G#) before it can make its expansion to the z-group, B-E-F-A# (m. 52). The delayed x-y and y-z expansions effected by the upward shifts of x and y are the means by which the new harmonic goal is reached. This new location of the z-group is the counterpart, in terms of the scheme outlined above, of its initial location in m. 22. In this position it will serve the development section as a harmonic focus. Bartok has here translated a traditional procedure of sonata-form into his own language.

For a typical illustration of the organizing role which this new version of the z-group plays in the development, we can look at the very beginning of that section (Ex. 11). The range of the material in mm. 54ff. extends vertically from the B^b of the first violin to the B of the cello, while the second violin maneuvers about E and the viola similarly about E#. The beginning of the recapitulation is signalled in mm. 91 and 92 by the playing of the x-group in its initial locus, C-C#-D-E^b.

Movement II appears to have for its crucial reference tones E-F (not just E, as Seiber indicates). This was the axis of symmetry of the z-group, B-E-F-A#, which initiated the development section of the first movement, and which was the counterpart of that group in its initial locus. The opening measures are organized by the inverted z-group, E-F-A#-B. The violins begin with E-F and work their way up chromatically, lingering in mm. 6-9 on A# and attaining the B at m. 10. During this ascent the viola and cello are limited by the range E-B, which shrinks gradually to the E-F of m. 10. At m. 33 the E-F axis is inverted and encloses a chord on all the white keys. E-F remains the oft-repeated focal point of the material through m. 64. At m. 65 begins a harmonic shift, the goal of which is a new central axis on C#-D at m. 68. The relationship between the two axes (E-F and C#-D) is seen in terms of the z-group (Ex. 12). The last pronouncement in the movement of the E-F axis is made in the three-bar cadence by the cello's descent from F to E.

I take the final illustration of the use of these devices from Movement V. It opens with the tune from which the z-group evolved in the first movement. This is accompanied in the cello by just such a group: C-G-D^b-F#. In mm. 42 and 43 the cello descends to a chord on A, and the violins at m. 45 play a z-group, A-B^b-D#-E. This is, in terms of the same scheme, the counterpart of the opening group, C-G-D^b-F#, and remains the harmonic base for the ensuing section through m. 72. In the latter measure the cello begins another descent which results in a return to the original group on C at 75.

The second z-group recurs in inversion (E-A-A#-D#) at m. 212-213 and serves once more as a reference. At m. 221 the cello and viola begin ostinato x-groups about the axis D#-E, the viola switching to the A-A# axis at m. 227. The initial z-group on C does not return, however. Where one might expect it there is a chord built, indeed, on C (m. 281), but composed of the fifths that have been prominent throughout the movement. There is no doubt a feeling of return to a point of origin here, but the sounds of the z-scheme have been replaced by what

can perhaps be taken to refer to the first sounds heard in the piece, the C-E. There is perhaps a reminder of the z-group in the C# which sounds as an appoggiatura to the fifths-chord. There is certainly a reminder in the tune, which is carried on until it is supplanted by the first subject of the opening movement.

It should be clear from the above that the C-ness, or C-E-ness, of this quartet is inadequate to account directly for any harmonic motion within the piece. Much of its harmonic and melodic make-up can, however, be interpreted in terms of the relationships involving the x-, y-, and z-groups. It remains now to consider what points of contact exist between the two.

First, the loci of the x- and y-groups in their initial appearances are partly bounded by the C-E center: the x-group is rooted at the bottom to C, the y is bounded at the top by E. These initial loci have the greatest consequence for the central pitch areas throughout the quartet. Thus, in the first movement the cello and viola ostinato which introduces the second subject (m. 14) is built around the y-group, B^{b}-C-D-E; the viola plays the C-D-E while the cello's figure pivots on A#. This certainly influences the pitch-location of the z-group which emerges from the second subject at m. 22 and thereby the consequent harmonic areas discussed above.

Second, the C-E provides bounds for the two key locations of the x-group in movement I: C-E^{b}, the original location, and C#-E at the end of the exposition (mm. 49-50), which has its consequences for the harmonic organization of the development section.

Finally, the z-group is directly linked to the C-center in Movement V, in that its initial location is built up from C, first in the viola, then on the same cello open-C which is heard in the first measure of the quartet.

* * * * * * * * * * *

RE: INTERVALLIC RELATIONS BETWEEN TWO COLLECTIONS OF NOTES

By David Lewin

Throughout this paper I shall use the word "note" to denote what would be more precisely called "name of a collection of pitches differing from each other by integral numbers of octaves." Thus, in my terminology, "440 vibrations per second" denotes a pitch, "880 vibs. per sec." denotes a pitch, "220 vibs. per sec." denotes a pitch, etc.; "A," however, denotes a note. In this sense, then, there are only twelve "notes."

From among these twelve notes, we may form various collections. There are 66 collections of 2 (different) notes, 220 collections of 3 (different) notes, 12 collections of one note, one collection of 12 (different) notes, etc.

One can define the interval between the note X and the note Y as follows: take any specific pitch whose name is "X" and count upwards in semitones through the tempered scale until you arrive at the first pitch whose name is "Y." The number of semitones you have counted is "the interval between X and Y." Thus, the interval between A and C is

3; the interval between C and A is 9; the interval between D and G is 5; the interval between G and D is 7; the interval between F and F is zero; etc. As is easily seen, the interval between the note X and the note Y is always an integer between zero and 11 inclusive.

Let P and Q be any two collections of notes. We impose no a priori restrictions on P and Q. P may contain 2 notes and Q, 7; or P may contain 4 notes and Q, 12, etc.; possibly, even, Q may be the same collection as P.

We can define what I shall call the interval function between P and Q as follows:

For every integer i between 0 and 11 inclusive, let m(i) (read "m of i") be the number of pairs of notes (x, y) such that x is a member of the collection P, y is a member of Q, and the interval between x and y is i. The function m will be called the interval function between P and Q.

Example: suppose $P=(C, E, G)$, $Q=(C, F, A^b)$.

Then m(0), the number of intervals of zero between notes of P and notes of Q, = 1, since C is a note of P, C is a note of Q, and the interval between C and C is zero.

E is a note of P, F is a note of Q, and the interval between E and F is 1. The same is true for G and A^b. Thus, since we have two such pairs of notes separated by the interval 1, we write m(1)=2.

The interval between E and A^b is 4, and E and A^b form the only such pair of notes from P and Q respectively. Thus m(4)=1.

The interval between C and F is 5; the interval between G and C is 5; these two are the only such pairs. Thus m(5)=2.

In like manner, we can see that m(8)=2, m(10)=1, and m(2)=0, m(3)=0, m(6)=0, m(7)=0, m(9)=0, and m(11)=0 (the latter intervals do not appear at all between notes of P and notes of Q).

The problem with which we will be concerned in this paper is the following:

Suppose we have collections P, Q, and R. Suppose the interval function between P and R is the same as the interval function between P and Q (i.e. for every i between 0 and 11 inclusive, the number of intervals i between notes of P and notes of R is the same as the number of intervals i between notes of P and notes of Q). Can we conclude that Q is the same collection as R?

The answer is yes, with certain qualifications, to wit:

We shall describe five properties, each of which any collection of notes may or may not have. The collection P will have certain of these properties (possibly none). If Q and R both have at least the same ones that P has, then the aforementioned question can be answered positively.

We now define the properties.

If P is any collection of notes, we shall say that P has the whole-tone-scale property if the number of notes P has in common with one whole-tone scale is the same as the number of notes P has in common with the other whole-tone scale.

We shall say that P has the diminished-seventh-chord property if P has the same number of notes in common with each of the three diminished-seventh chords.

Let T_0 be the augmented triad C-E-G#.
Let T_1 be the augmented triad C#-F-A.
Let T_2 be the augmented triad D-F#-A#.
Let T_3 be the augmented triad E^b-G-B.

We shall say that P has the augmented-triad property if P has the same number of notes in common with T_0 as it has in common with T_2, and also has in common with T_1 the same number of notes that it has in common with T_3.

Let Q_0 be the tritone C-F#; let Q_1 be the tritone C#-G.
Let Q_2 be the tritone D-G#; let Q_3 be the tritone D#-A.
Let Q_4 be the tritone E-A#; let Q_5 be the tritone F-B.
Let n_0 be the number of notes P has in common with Q_0.
Let n_1 be the number of notes P has in common with Q_1.
Let n_2 be the number of notes P has in common with Q_2.
etc.
(Let n_5 be the number of notes P has in common with Q_5.)

We shall say that P has the tritone property if

$$n_1 - n_4 = n_3 - n_0 = n_5 - n_2.$$

We shall say that P has the exceptional property if P is one of the following collections:

1. a tritone;
2. all notes except a tritone;
3. an augmented triad;
4. all notes except an augmented triad;
5. a four-note collection containing two tritones, e.g. such forms as C-D-F#-G#, C-C#-F#-G, etc.;
6. all notes except a four-note collection having one of the above forms;
7. a five-note collection consisting of an augmented triad plus a tritone;
8. all notes except a five-note collection of the above form;
9. any six-note collection consisting of three tritones, e.g. such forms as C-C#-D-F#-G-G#, C-D -E -F#-G-A, or a whole-tone scale;
10. an Ode to Napoleon hexachord, i.e. a hexachord of form (C, C#, E, F, G#, A).

Our five properties, then, are: the whole-tone-scale property, the diminished-seventh-chord property, the augmented-triad property, the tritone property, and the exceptional property. A collection P may have any one of these properties, or several of them, or none of them.

The result which this paper communicates is the following:

If P, Q, and R are collections of notes, and if both Q and R enjoy at least the same of the above five properties as does P, and if the interval function between P and R is the same as the interval function between P and Q; then Q and R are identically the same collection.

As a special case of this result, we have the following:

If a collection P has none of the five properties, then every collection Q is uniquely characterized by its interval function with respect to P.

The mathematical reasoning by which I arrived at this result is not communicable to a reader who does not have considerable mathematical training. For those who have had such training, I append a sketch of the proof:

Consider the group algebra of the additive group of residues mod12 over the complex numbers. With the collection P we associate f, the characteristic function of P ($f(x) = 1$ if $x \in P$; $f(x) = 0$ if $x \notin P$).

If g is the characteristic function of Q, then the interval function m between P and Q is given by: $m = g * f^*$ ($m(i) = \sum_y g(y)f(y-i)$).

If h is the characteristic function of R, and $h * f^* = g * f^*$, take the Fourier transforms: $H\overline{F} = G\overline{F}$. Thus $G = H$ wherever F does not vanish. Since f is real-valued, F is self-adjoint, and we need only consider the possibilities of F's vanishing at 0, 1, 2, 3, 4, 5, and 6.

$F(0)$ is the number of notes in P, so $F(0) \neq 0$.

By computing, we can show that $F(1) = F(5) = 0$ if and only if P has the exceptional property. $F(2) = 0$ is equivalent to the tritone property for P; $F(3) = 0$ gives the augmented-triad property, $f(4) = 0$ the diminished-seventh-chord property, and $F(6) = 0$ the whole-tone-scale property.

Therefore, if Q and R enjoy at least the same properties from among these five as does P, then both G and H vanish wherever F vanishes; hence, $G\overline{F} = H\overline{F}$ implies $G = H$, which implies $g = h$, which implies $P = Q$. q.e.d.

BOOK REVIEWS

Edited by
George H. Jacobson

EXPERIMENTAL MUSIC. Composition with an Electronic Computer. By Lejaren A. Hiller, Jr. and Leonard M. Isaacson. McGraw-Hill Book Co., New York, 1959, 197 pp., $6.00.

The subtitle of this book is more to the point than the title. The authors' primary concern is not experimental music in general but a particular set of musical experiments they carried out with an electronic computer. A brief discussion of other forms of experimental music is included, but this discussion together with much of the other background material (evidently included because of the authors' laudable intention to make the implications of their work clear to both musician and mathematician) often makes the book seem padded. Its hard core, however, a solid report on the assumptions, methods, and results of their experiments, is of major interest for both analyst and composer.

In these experiments the authors programmed the Illiac, a high-speed digital computer, to generate music. A representative sampling of the Illiac's output, the Illiac Suite for String Quartet, was first performed in 1956 and was published in 1957 by New Music Editions. The complete score is included in Experimental Music.

The following method was used: The characteristics of sound which were to be organized (pitch, timbre, dynamics, rhythm) were coded into numbers so that all potential relationships between these characteristics could be stated as simple arithmetical operations. (The relationships used were interval for pitch and simple identity or non-identity for the other characteristics.) The machine could then deal with these numbers and operations according to a set of operating instructions. These instructions were mathematical formulations of those laws assumed to govern the kind of music desired. In the first two movements (or, as they are called, "Experiments") of the Illiac Suite, the governing laws were the restrictions of first-species counterpoint. In Experiment III, the authors' attention was concentrated on the coding of timbres, dynamics, and rhythmic patterns. The only governing law for melody was a rule preventing two successive skips; the only one for harmony assured the proper resolution of tritones. In Experiment IV, the principle of a Markoff chain was used to develop the governing laws. The likelihood of each successive note in a line was governed by a set of weighted probabilities assigned to the interval which would be formed by that note and some other note. In most sections the other note was the one immediately preceding the note in question. In others it remained the first note of the section throughout that section. In the last section, the strong-beat notes were related to the last note of the section by one set of probabilities while weak-beat notes were related to the immediately preceding strong-beat notes by another set. Since, in the former set, probabilities were higher the more consonant the interval, and, in the latter, the smaller the interval, the result presented

a rudimentary form of tonality in which melodic and harmonic factors were both present, yet did not interfere with one another because of their position in a hierarchical metric scheme.

The actual production of music using these governing laws was achieved with the Monte Carlo method. The computer generated a series of random numbers. Its operating instructions enabled the computer to decide which of these numbers represented pitches (or any of the other characteristics) that would be in accord with the governing laws and which not. Only the former were recorded on the output tape which was then decoded into music.

An examination of the Illiac Suite shows that the computer was far from justifying the claims of the newspapers: "Illiac — Mechanical Brain — Takes Up Composing Music," "'Brain' Makes like Bach for Scientists" (p. 6). The authors are careful to point out in their introduction that the Illiac Suite "was meant to be a research record — a laboratory notebook" (p. 5), not a work of art. To argue at the present time that a computer composes music is to use a restricted definition of either "compose" or "music." The music of the Illiac Suite is characterized by a high level of control only in the extremely limited world of first species; in less limited situations it shows a much lower level of control than man-made music. The limited nature of this machine-made music is not due to the limited nature of the machine but to the limited nature of our knowledge about man-made music. The human brain can handle efficiently so many of the complexly interwoven governing laws necessary to the composition of music without being aware of their exact logical structure. It may be that mechanical brains could handle such laws more efficiently, but we cannot know at present, since, until we are aware of the exact structure of these governing laws, we cannot program a machine to use them.

Nevertheless, we do know some of these laws, or rather we have some hypotheses, and programming a computer to generate music on the basis of these hypotheses is a highly reliable way to check their accuracy. As the authors point out:

> A computer is an ideal instrument by means of which analytical ideas can be tested, since the investigator starts with certain hypotheses from which he formulates operating principles; he supplies this information to the computer; the computer then generates music based upon these principles; and the investigator then analyzes the results to further his investigation (p. 166).

When the human brain makes such an experiment, it is all too apt unconsciously to be affected by governing laws other than those it is testing; consequently the results may be misleadingly favorable. What makes the mechanical brain so reliable as an analytic tool is precisely what makes it so inadequate as a composer: it supplies nothing that is not in its program; the only non-random properties in its output will be the result of a known input, the governing laws in question. The limitations of its output as music work to our advantage in analytic projects; such output serves as a perfect aural model of what we do and what we do not know.

It is to the analyst's further advantage that the variety of oper-

ating principles already worked out for the Illiac Suite gives him a number of starting points from which his attack on certain long-standing problems of theory can converge. For example, an investigation of the governing laws of 18th- and 19th-century music might begin along two lines. The first would use the methods of Experiments I and II. It is possible to view the restrictions of species counterpoint not just as a convenient set of training rules, but as the underlying principles in the set of governing laws for the music of these two centuries. The frequency with which these rules are broken on the actual surface of this music constitutes not so much a denial of these principles as a set of qualifications (cf. Schenker). Such qualifications could be rationalized into a network of secondary operating principles, and the output thus generated could be compared against actual examples to test the validity of our rationalizations. Any deficiencies of the computer's output would help suggest new rationalizations.

The other approach would follow the methods of Experiment IV, but instead of using the set of weighted probabilities suggested by some "natural" order (as proximity or consonance), the analyst would use probabilities derived from a statistical analysis of actual examples. Deficiencies in the computer output would indicate a need for higher order Markoff chains or for greater selectivity in the relationships being considered.

These two approaches have different advantages: the first can make use of certain brilliant assumptions of past analysts; the second requires fewer assumptions, nor need the analyst be brilliant. However, the two approaches are complementary. Furthermore, they will converge as soon as the analyst using the first finds it advisable to consider the probability (within a particular style) that one qualification will be used in a certain situation instead of another, and the analyst using the second finds it advisable to consider the effect of the position of a note in some hierarchy (say rhythmic) on its probability.

The authors do not suggest such a program, although it would seem to me a prerequisite to successful use of the computer for the kind of practical task (realizing basso continuo parts, for example) that they do suggest. They do, however, have a basic analytic program and one that is far more sweeping. It would be based on the premises

> that most musical compositions reflect a balance between the extremes of order and disorder, and that stylistic differences depend to a considerable extent upon fluctuations relative to these two poles... [and]... that interest in musical structures is achieved normally when fluctuations around some stylistic mean between these two poles are also subject to processes of organization and arrangement timewise within the structure (p. 167).

The clarification of the relationship of the listener's interest to entropy which might result from such a study would be particularly welcome.

Obviously any clarification of analytic processes may be of indirect use to composers. But direct use of a computer for composition is also possible, if only in a limited way. I do not think, however, that many composers will feel the need for output generated by present methods extended to handle "many of the traditional and contemporary

harmonic practices...[or]...the writing of standard closed forms, such as variation-form, fugue, song-form, sonata-form, etc." (p. 170). Such output will be of more use to the analyst for some time to come. More proper to composition is the authors' projected use of random properties as "a formal element to be integrated into musical structures" (p. 171). To give such a positive position to entropy would seem at variance with the authors' premise quoted above that interest is a function of the effect of ordering on the fluctuations of the relative entropy determined by style, but the positive use of random factors is fashionable among some composers today,[1] and a computer using the Monte Carlo method would be ideally suited to their needs. Not only is the machine strikingly more efficient than a man for such processes, but the programming is much easier than the programming for such highly determined processes as simple first species.

I would be more interested in the development of procedures less efficient for the composing machine and more efficient for the listening man. For example, the authors suggest that the Markoff chain methods which produced the pseudo-polyphony of Experiment IV might be refined to include intervallic probability between as well as within lines. How these probabilities would be weighted is a matter of style. The authors have weighted intervals according to two "natural" orders. But in some styles the composer makes his own order for each piece. Consider, for example, a style in which local sequences are minimized (as in much twelve-tone music), and circulation of the twelve-pitch classes within lines and between lines is maximized (as in Schoenberg), but in which the variety of interval classes between lines as well as within lines is minimized (as in some Webern). Methods for generating music with each of these characteristics singly have already been developed for the Illiac Suite. A combined coding would be involved but possible. The machine would print on its output tape only a tiny proportion of the random numbers generated, but this very restrictiveness would be the listener's gain. Indeed, the composer might decide that the more restrictive, the better. The machine might then be programmed to generate a large number of experiments but to record only those which were more restrictive than the last one recorded. Consequently the composer need decode only the final entry.

Such a procedure would represent a further development of the machine's capacity to sort out the organized from the disorganized, and thus a further step towards composing. Of course the machine still makes its decisions according to considerations chosen by the man. The realization of the machine's potential ability to set up the bases for decisions must await considerable clarification of the logical structure of those bases. But as this book shows for the first time, the machine

1. Notably the composers who used to write that "totally organized music" which the authors suggest is "particularly suitable for computer processing" (p. 171). Yet there would have been no gain in efficiency had they used computers, for all the characteristics of a piece were either predetermined by a precompositional scheme (a magic square, for example) or determined intuitively by the composer. It was just as easy to decode the notes directly from the scheme as it would have been from a computer tape.

itself may prove highly valuable in helping to provide just such a clarification.

PETER WESTERGAARD

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ANONYMOUS IV. Translated and edited by Luther Dittmer. Institute of Medieval Music, Brooklyn, N.Y., 1959, 72 pp., $7.50.

ROBERT DE HANDLO. Translated and edited by Luther Dittmer. Institute of Medieval Music, Brooklyn, N.Y., 1959, 44 pp., $7.00.

"Translations are like women: if they are faithful, they are not beautiful; if they are beautiful, they are not faithful!" Presumably the author of this complaint would have seen no relationship between the translations at hand and the representatives of the fair sex: they are neither faithful nor beautiful. Admittedly, Mr. Dittmer does not begin with compositions whose chief merit lies in their literary excellence. Nevertheless, if it is unreasonable to ask for beautiful translations, it is not unreasonable to demand that they reproduce accurately, and with some degree of clarity and fluency, the sense of the original documents. That they fail to do so is unfortunate, for the works which Mr. Dittmer has chosen to bring, through translation, to a wider public are important sources of information about the rhythmic theories and practices of the 13th century.

The treatise of the so-called Anonymous IV[2] deals in considerable detail with the subject of modal or pre-mensural rhythm: the basic principles governing that rhythm, the means of notating it, and its application to polyphonic composition. Written about the year 1275, it is specifically referable to the music of the Notre Dame (Paris) school, which flourished from c. 1180 to c. 1240.

By even the minimum standards of acceptable scholarship, Mr. Dittmer's translation of the Anonymous IV treatise must be judged worthless. The consistent misspellings (ia, equivilent, dischord); the use of non-existent forms (calliographically), and the misuse of existing ones (illusion for allusion); the succession of clumsy, often grammatically unsound sentences; the undetected omission of material from the body of the text (one whole paragraph in Ch. 6[3]): all of these should make the work suspect, even in the eyes of one utterly innocent of either medieval or musical pretensions. Unfortunately, these errors — in themselves, perhaps, more exasperating than serious or harmful — are symptomatic of more profound weaknesses, genuinely deleterious

2. The treatise appears in the 1st volume of Coussemaker's Scriptorum de Musica Medii Aevi as the fourth of a group of seven treatises whose authors have not been identified by name.

3. The 3rd paragraph of Ch. 6 begins: "The 3rd volume is one of 3-voice conductus with caudae, etc." The paragraph which stands 3rd in Mr. Dittmer's reading should then follow as the 4th: "There is another (aliud) volume of 2-voice conductus, etc." The confusion resulting from this omission is compounded by the fact that the 1st footnote on p. 66 applies to the missing paragraph.

in their consequences. The same casualness which characterizes Dittmer's orthography and grammar extends to his translation of certain of the terms basic to an understanding of the theory of modal rhythm. Thus, in the glossary provided at the head of the treatise we find the following definitions:

> perfectio and pes: perfection
>
> longa imperfecta: the long durational value of two units, as opposed to the longa perfecta of three

It is well known that the rhythmic modes in music were conceived of as analogous to the poetic modes; that is, they were based upon a series of long and/or short values arranged in groups known as feet (pedes). Now it so happens that the composers who wrote within the framework of the rhythmic modes limited themselves to feet consisting of a total of 3 temporal units (tempora): a long of 2 and a breve of 1 (or vice versa), 3 breves of 1 each, or 1 long of 3. In the case of the 3rd and 4th modes the basic metrical patterns required the use of 2 such feet, but each foot still had this basic complement of 3 temporal units, arranged in a specific, predetermined way. Anonymous IV is consistent in his identification of these groups as feet. Not once in the entire treatise does he use the expression perfectio which Mr. Dittmer has presumed to equate with pes. No less consistent is the author in his description of the longs which are used. These consist of 2 temporal units or they consist of 3 temporal units and are so indicated. There is no question of perfection or imperfection. The terms do not appear, and this for the simple reason that the concept did not exist.

Mr. Dittmer is not, to be sure, the only one who makes the mistake of assuming for the modal theory premises which rather undergird the theory of the succeeding, Franconian period. It is during this later period that the concept of perfection evolved: the idea of a basic ternary measurement which was, of itself, perfect or complete; one which could be arrived at by various combinations of elements; and one which could be made imperfect by having something subtracted from it, either at the beginning or the end. To the mind of the pre-mensural theorist, on the other hand, successive feet constituted an underlying, on-going meter in no way subject to perfection, imperfection, lengthening, shortening, or interruption; simply a kind of continuum, marked off into phrases of varying length by the introduction of rests. A correct reading of Anonymous IV would do much to clarify the distinction between these two views of rhythmic organization.

The terms perfecta and imperfecta are employed by Anonymous IV, but to indicate what we might call normal or regular phrases in a given mode as opposed to abnormal ones. For example, a phrase in the 1st rhythmic mode is perfect if it concludes on the 1st part of a foot: . It is imperfect if it concludes on the 2nd part of a foot: .

The arbitrary reading of pes has the effect of distorting an entire theory. A multitude of more localized errors serve to misrepresent specific practices illustrating that theory. Three such errors are singled out here for correction and comment.

On p. 14 we find some 4 versions of this rather puzzling formulation: "The next 3 notes after this are both formed and conceived of as ligated." The Latin reads: "... deinde tria conjuncta, actu vel intellectu ..." The author has but recently pointed out that, wherever possible, notes should be joined in ligature. However, two notes of the same pitch, for example, cannot be so joined, and it is therefore necessary to imagine them as joined. This is of no small significance in the reading of modal notation, and the foregoing sentence, properly read, expresses this perfectly clearly: "... then [come] 3 notes actually joined, or imagined to be."

In a footnote to the paragraph concluding at the top of p. 21 Mr. Dittmer observes that the meaning of the passage is not quite clear. This is certainly so if we accept his reading which is as follows: "... which is difficult in such sciences unless they (ternary longs) are changed from long durational units to more accomodating (sic) ones." This does some violence to Anonymous IV's simple observation that it takes long practice to handle these matters skillfully. "... quod difficile est apud talia scientes (not sciences, but [those] studying), nisi fuerint a longo tempore (for [lit: from] a long time) ad talia consueti."

In the section on discant (Ch. 5, p. 59, et passim) Mr. Dittmer misreads "infra diatessaron et diapente, etc." which means here "within the interval of a 4th or 5th," not "the 4th or 5th below." The latter reading does not account for the contrary motion of the voices. It further comes into conflict with the fact that while the parts do cross, the general procedure is to begin with the lowest (tenor) voice and to add parts above it, not below.

There is little need to dwell upon matters editorial. Mr. Dittmer might have noted (as Coussemaker was careful to do) that the various chapter headings and subtitles used are not present in the manuscripts. Also, that the musical illustrations do not appear in the original treatise, but have been deduced by the translator. The value of notes commenting upon the text is questionable in the light of a reading so hugely and so fundamentally inaccurate.

As Vol. 2 of Musical Theorists in Translation Mr. Dittmer has published the early 14th-century treatise: Rules, with Maxims, of Master Franco, plus other musicians, compiled by Robert of Handlo.

The "rules and maxims of Master Franco" pertain 1) to the use of distinctive note forms to indicate the values of long, breve, and semibreve; and 2) to the normally perfect or ternary relationship between long and breve and between breve and semibreve. No mere traditionalist, however, the author, whose compilation was completed on the "Friday next before Pentecost in the year of Our Lord one thousand three hundred and twenty-six," records many post-Franconian developments in rhythmic practice and cites Petrus de Cruce, John Garland (the second of that name), and Petrus le Viser in support of them.[4]

Covering as it does a relatively long span of time in an era when changes in practice were occurring very rapidly, the work is burdened with a number of contradictions and conflicting data. Older practices have not been discarded, but are maintained along with the new. The

4. The most important of the new developments involves the subdivision of the semibreve into minoratae and minimae.

most up-to-date theory of the binary division of long, breve, and semibreve is not even discussed, although the epoch-making treatise of Philippe de Vitry must have appeared at almost exactly the same time as this one of Robert — perhaps even a few years earlier. It is to be assumed, then, that Robert describes the musical practice of some area peripheral to the center of the most progressive musical activity of the early 14th century, that is, northern France. He is generally believed to have been an Englishman.

Robert's treatise fares ever so little better in the hands of Mr. Dittmer than does that of Anonymous IV. The presentation of the translation is just as slovenly, but the real errors in translation are, mercifully, fewer in number.[5]

Mr. Dittmer has elected in many instances to substitute his own musical illustrations for those, often faulty, provided by the manuscript. We would like to make two suggestions with regard to his treatment of the examples. First, where it is a matter of presenting or describing note-forms as such, there is no value in providing modern metrical equivalents. Second, where a matter of interpretation of the note-forms is involved and a modern equivalent is in order, let that equivalent be thoroughly modern: let the perfections be marked off by bar-lines.

Toward the end of the treatise Robert illustrates a number of his rules with quotations from well-known compositions of the time. One such quotation is of a fragment of one of the tripla from the famous St. Catherine motet, Agmine milicie. Mr. Dittmer devotes at least a full page to a discussion of the sources of the motet and to a transcription of the several versions (including a French contrafact) of the first phrase. The reason for printing all the voices of the motet is not clear since it is only the voice with the smaller note-values which illustrates the rule cited by Robert. Neither is the reason for the lengthy footnote on p. 42 clear. The discussion is not particularly relevant to the treatise and furthermore, these very materials are exhaustively dealt with in an article published by Friedrich Gennrich in the Zeitschrift für Musikwissenschaft, XI (1928-29). In addition to quoting all the sources named by Mr. Dittmer (as well as two others: Las Huelgas and Egerton 2615), Gennrich printed the music, complete, for all the known versions of the motet.

It is easy enough to write off as unsatisfactory the work which Mr. Dittmer has presented here. A dismissal of the translations, however, does not dispose of what is, in the opinion of this reviewer, an extremely serious issue: that of an apparent lack of integrity of workmanship. Surely there is no one in the field of historical research who should be unsympathetic to the problems faced by Mr. Dittmer or by anyone else engaged in the preparation of such materials. No one may lay claim to infallibility in reading texts which are strenuously abbreviated, sometimes corrupt, often expressed in unfamiliar terminology. Anyone who has undertaken the most modest investigation of a medieval problem lives in dread of missing some vital relationship or of over-

5. For examples of the most glaring errors, v. p. 11, Rule XI, where the dialogue structure is overlooked, and p. 18, Rule XVI, where minorata and minima are incorrectly made the equivalents of semibrevis maior and semibrevis minor.

looking some of the significant critical literature on the subject. Nevertheless, there are precautions which anybody who calls himself a student is under obligation to take. Requisite before all else is an affirmative answer to the question of one's basic qualifications for taking up a particular assignment: in this case, for example, a firm grasp of the principles of Latin grammar. Once granted this primary qualification, a translator is still unwise to attempt to present his work without benefit of examination by others competent to judge its value. It is for this reason that translators often work in pairs and that they almost always submit their work to the critical and impartial eye of an editor. Perhaps before continuing with his ambitious plans for publication, Mr. Dittmer can be encouraged at least to share with qualified individuals certain phases of what is surely a worthwhile undertaking.

It is embarrassing to contemplate the scorn with which those from other disciplines might well view the examples of musicological scholarship here offered. It is distressing to imagine that anyone within the field might accept them either as sources of accurate information or as models of procedure.

JANET KNAPP

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CONVERSATIONS WITH IGOR STRAVINSKY. By Igor Stravinsky and Robert Craft. Doubleday and Co., New York, 1959, 162 pp., $4.00.

This book is sometimes amusing, occasionally illuminating, and frequently exasperating. Especially does the element of annoyance enter in when we attempt to extract from these "fireside chats" anything like a consistent exposition of Stravinsky's current theories. In all fairness, it must be admitted that such an exposition was probably not intended by either the composer or his interviewer. However, I would have gladly dispensed with a handful of the princely and royal names that liberally besprinkle these pages in favor of a few more concrete statements about music.

The work is divided into four sections: "About Composing and Compositions," "About Musicians and Others," "About My Life and Times and Other Arts," and "About Music Today." The reader who can get past the first section will find himself rewarded by many comments of interest (sometimes perceptive, sometimes less so) about Stravinsky's contemporaries in various fields of artistic activity. But that first section is very disconcerting. Reading it, one feels as if one had wandered uninvited into some literary cocktail party at which each conversationalist is trying to show his cleverness as advantageously as possible without paying too much attention to what others around him are saying. Thus, one may often have the curious impression that either Craft is asking the wrong questions or Stravinsky is giving the wrong answers — or, at least, giving them with tongue in cheek. Thus, to a question of Craft's about the meaning of the phrase "the weight of an interval," Stravinsky replies, in part, as follows: "After working late one night [on Threni] I retired to bed still troubled by an interval. I dreamed about this interval. It had become an elastic substance stretching exactly between the two notes I had composed, but under-

neath these notes at either end was an egg, a large testicular egg. The eggs were gelatinous to the touch (I touched them) and warm, and they were protected by nests. I woke up knowing that my interval was right. (For those who want more of the dream, it was pink—I often dream in color.)" One can scarcely help wondering, "Who's kidding whom?"

Of course, the most-discussed element in Stravinsky's recent works has been his turn to twelve-tone, serial writing. Therefore, we look with interest to see what he may have to contribute to the theory of this method. Rightly he points out, "... my recent works are composed in the — my — tonal system." Thereby he tacitly rejects, as Schoenberg always openly did and as Stravinsky himself long ago did in his Poetics of Music, the meaningless term "atonality." Webern, he makes clear, is his patron saint and protector in this new serial world: "I do not hesitate to shelter myself by the beneficent protection of his not yet canonized art." This new faith leads him to make a declaration which would have been unthinkable in the mouth of the Stravinsky of thirty years ago: "... a masterpiece is more likely to happen to the composer with the most highly developed language. This language is serial at present, and though our contemporary development of it could be tangential to an evolution we do not yet see, for us this doesn't matter. Its resources have enlarged the present language and changed our perspective in it. Developments in language are not easily abandoned, and the composer who fails to take account of them may lose the mainstream. Masterpieces aside, it seems to me the new music will be serial." (Italics mine.) This is an excellent statement but leaves the serious reader desirous of more specific analyses of Stravinsky's own twelve-tone procedures. What exactly did he learn from Webern? How exactly did he adapt it to his own uses? We do learn that he is fascinated by the handling of "vertical density" (to use a more fashionable term than "harmony") in the works of Webern; this, indeed, he considers "a fact so remarkable that I wonder if even Webern knew who Webern was." One might comment that Webern probably knew who he was rather better than do some of his imitators; one might also point out that, in order to know who Webern was, it is helpful first to know who Schoenberg was. This state of knowledge might be thought a little shaky in one who "could bear the loss of [Schoenberg's] first nineteen opus numbers" (with the single exception of the Five Orchestral Pieces) and who can say "the unison Adagio in his fourth Quartet makes me squirm."

How may the new techniques, methods and theories be taught to the aspiring young composer? Here Stravinsky is rather unhelpful: "A composer is or isn't; he cannot learn to acquire the gift that makes him one, and whether he has it or not, in either case, he will not need anything I can tell him." The strict observance of this dictum would lead to widespread unemployment in our university music departments. This condition, however, Stravinsky would presumably view with equanimity, for he cautions, "I would warn young composers too, Americans especially, against university teaching. However pleasant and profitable to teach counterpoint at a rich American Gymnasium like Smith or Vassar, I am not sure that that is the right background for a composer." Messrs. Schoenberg, Hindemith, Milhaud, Krenek, Sessions, Piston, Stevens, Harris, etc., etc., seem to have felt rather differently on this point — to the detriment neither of themselves nor

of their many students, we might add.

As may readily be seen, this book will furnish much entertaining material for discussion — not to say controversy — in many a class on contemporary music, as well as in more informal surroundings. However, I should prefer to remember Stravinsky by the austere grandeur of his Threni, and Craft by his masterly performance of that work. These, I suspect, will endure after the "Conversations" have been forgotten.

DIKA NEWLIN

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COUNTERPOINT based on 18th-century practice. By Kent Kennan. Prentice-Hall, Englewood Cliffs, N.J., 211 pp., and Workbook, 57 pp., $6.60.

There is nothing particularly new about this contrapuntal duo. What we can loosely call 18th-century counterpoint (and Mr. Kennan does) is systematically gone over here with clear-headed precision and thoroughness. It is in these latter attributes that the merits of these volumes lie.

The attitude of the author is clearly that of the college or university instructor who wishes to pass on to students both contrapuntal skill and understanding. The result, in these works, is an uncluttered testament to his success. The text covers enough ground for about a year of intense study for students who have passed through the usual two years of "theory," including analysis of altered chords of the usual 18th-century complexity. The workbook follows the text with calculated ease, and the work problems incorporated therein should be a pleasant treasury for the most supercilious of "workbook" opponents.

The text (and the workbook in parallel) begins with an analysis of the melodic style of the period in question. Melodic curve, range, intervallic structure, harmonic implication, and certain rhythmic and morphological peculiarities of 18th-century melody are dealt with in the first chapter. This is followed by three chapters of modified "species" two-part counterpoint and one chapter in which motive development and the two-part invention are studied.

Three-part writing, again in simplified species form, is introduced in a single chapter, a section treating the three-voice invention following. The remainder of the text is devoted to the formal procedures to which a contrapuntal texture can be fitted: the canon, chorale forms, invertible counterpoint, and fugue. The latter subject, in its manifold of complexities, consumes the three final chapters of the book. The Workbook accompanies the text through the first of the final three chapters, ending with subjects for use in exercises in strettos or complete fugue composition.

The publisher has done the expected excellent job of design and printing, even to the extent of a "fashionable" brown, black and white color scheme for the hardback text. Both volumes are of functional proportions, the Workbook a paperback slightly larger than the text to allow suitable room for the student's manuscript solutions to problems.

If there are mistakes in the volumes they are negligible, except

for the omission of a one-flat signature in Ex. 5 on p. 75. This oversight leads to confusion, for the lack of a B^b precludes the tritone with E about which so much fuss is made in the accompanying text. I am afraid that most students would be stumped by this one, and some instructors would be cost a studied search.

The final chapter will probably be "the section we got to at the end of the year" for most counterpoint classes, for in dealing with six- and seven-voice textures, double and triple fugues, et al., it goes quite beyond the year's course suggested above. But its inclusion here is, I am certain, for reasons of thoroughness rather than overambitious presuppositions. Any class will know, after a careful reading of this chapter and a study of a few of its suggested sources, exactly what two types of triple fugue, for example, one might expect to come across in musical literature. For this reason alone the section is justified, even in this intended "primer" of counterpoint.

Some counterpoint instructors with overdeveloped senses of historical propriety might take offense at the liberal attitude Mr. Kennan has adopted toward what can be called "18th-century contrapuntal style." The technique introduced here is for the most part documented by examples from the WTC and Bach's Inventions. But sprinkled through the text are excerpts from such diverse sources as Byrd, Brahms, and Franck. My own opinion is that since each example serves the purpose effectively, I would find the choice of examples plausible.

My only real argument with the books is leveled not at Mr. Kennan but at an area of confusion that his Counterpoint perpetuates in common with just about every other work in this field of music instruction. I speak of the terminology for non-harmonic tones, a really simple matter upon which none of us seems willing to agree. The student who has been through the Hindemith Traditional Harmony will have an initial feeling of bewilderment when he finds that Kennan, like McHose and Piston, calls "auxiliaries" and "neighboring notes" what Hindemith refers to as "changing tones." On the other hand, what Hindemith calls "neighboring tones" are, in Kennan's book, labeled "changing tones." (I wish to imply no preference for either system, for the problem is not musical, but semantic.) For the sake of students I emphatically believe that we should get together on such simple matters.

Except for this single specific criticism, for which Mr. Kennan shares only partial blame with most respectable company, the two Counterpoint books are in my opinion the best available for a course in 18th-century counterpoint.

WILLIAM THOMSON

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TONAL COUNTERPOINT IN THE STYLE OF THE EIGHTEENTH CENTURY. By Ernst Krenek. Boosey and Hawkes, New York, 1958, 44 pp., $1.50.

An outline of 18th-century counterpoint such as this latest volume of Mr. Krenek should certainly serve a useful purpose. The author's intention, as he himself states in the preface, is "to present the subject matter in concentrated form for the use of teachers and students who

can devote only a limited amount of time to the study of tonal counterpoint!"

Familiar as is the sound of baroque counterpoint, there is something escapes us when we try to organize the techniques and ingredients of this style to make a meaningful presentation to students. There is undoubtedly more divergence of procedure in teaching counterpoint than in teaching any of the other theoretical approaches to music, and even individual teachers probably vary their own counterpoint courses from year to year more than their other courses.

It is difficult enough to achieve a certain degree of universality in writing a complete counterpoint text, and admittedly more so in condensing the material into the form of an outline. What this little volume could have gained in compactness it has lost somewhat by being too sketchy.

There is certainly no reason to deny that the individual teacher and student must be expected to fill in the gaps, but an outline can only be judged on what is actually there in print, and whether sufficient material is presented, brief as it may be, in order to form the skeletal framework for a complete understanding. There is no reason to doubt that an effective counterpoint course could successfully use this little volume as an outline, but it would seem that some things would have to be added that might very well have been included here, and some of the things which are included seem too elementary for this particular point of development in the student's musicianship. The latter is especially true of the section on rhythm, where the student is shown how whole-notes and half-notes are divided into quarters, eighths, etc.

A few points of omission are as follows:

1. Some reference to active degrees of the scale in the section on melody-writing.
2. Attention to the characteristic starting of motives on short rests. Most of the examples throughout the book tend to ignore this.
3. The tendency for sequences to progress melodically stepwise up or down from one unit of the sequence to the next.
4. Some reference to the more usual pitfalls encountered by students when using four notes to the beat.
5. Some reference to the typical baroque down-a-fifth or up-a-fourth root-motion in sequence (with and without inversions).
6. Reminder that parallel fifths and octaves are poor not only between adjacent pairs of notes but also from one metrically strong point to another.
7. Reminder that chromatic passing-tones in rapid motion are not characteristic.
8. Reference to double suspensions in thirds or sixths.
9. Some reminders of the more linear aspects of things learned in harmony classes, such as

   (a) preparing the seventh of the secondary or subordinate seventh chords.
   (b) careful handling of six-four chords.
   (c) avoidance of awkward harmonic syncopations.
   (d) avoidance of awkward anticipations.

Particularly meaningful is the author's theory of energy in melodic line. This is something which is frequently overlooked and yet is an essential, although sometimes elusive, ingredient.

The musical examples written by the author to illustrate each point as succinctly as possible are clear and free from divergent problems, although a few spots in the examples of three-part counterpoint might provoke some discussion as to whether or not they are characteristically of the 18th-century, even though logical.

This and the other points of criticism mentioned above should not divert one from the observation that many of the bare essentials of 18th-century counterpoint are included, and although one is apt to find the points of disagreement more interesting material for discussion than the points of agreement, this should in no way detract from the central bulk of the book, which most musicians and teachers will find to be good, sound pedagogy.

LELAND PROCTER

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EAR-TRAINING AND SIGHT-SINGING. By Maurice Lieberman. W.W. Norton and Company, Inc., New York, N.Y., 1959, 326 pp., $4.95.

As in his earlier text, Keyboard Harmony and Improvization, Mr. Lieberman supplies much more than the minimum requirements of a text on his specific subject. As Mr. Gerschefski pointed out in his review of the earlier text (Journal of Music Theory, I:218-19), it embraces most of the components of correlated theory. Ear-Training and Sight-Singing is more restricted in scope, but in the first three chapters, which cover some 46 pages, the author has discussed rhythm, tonal characteristics, form, syncopation, the V_7-chord and mixed meters, plus a number of additional topics. The melodies for singing first appear on page 47, and out of the 326 pages in the book, approximately 214 are devoted to sight-singing material, the remainder to explanations. The book is divided into 14 chapters, of which the first 5 are devoted to major diatonic melodies, the next 2 to minor diatonic melodies, and the remaining 7 to chromatic and modulating melodies.

It may seem unkind to cavil at the inclusion of so much written material, but the closer a "skills" text is to being a basic text itself, the more difficult it becomes to reorganize it in terms of the basic text or syllabus used as the core of the course. Most basic texts cover intervals very early in the course; Leiberman discusses the major 6th in Ch. 3 (p. 43) but the minor 6th is not introduced until Ch. 7 (p. 111), where it appears as an interval within the harmonic minor scale. The interval of the major 7th appears on p. 185, where it is introduced as a part of the major 7th-chord. This is a logical organization, but in most theory classes the interval of the major 7th is introduced much earlier than this placement indicates. One might be in the position of trying to correlate the work of the first two years of theory with the sight-singing text instead of vice-versa — a somewhat unusual procedure. An unfortunate aspect of attempting to cover so much material in a book of this type is that each item must necessarily be treated in a too-cursory manner. Since this material is usually covered in detail

in other sections of the theory work, this amounts to an unnecessary duplication, and without the redeeming virtue of a more illuminating discussion.

These problems of organization might have been explained in an author's preface, but there is none. This is unfortunate for a number of reasons: we are given no idea of how the author uses the material or intends us to use it; his approach to the problems involved in such a course is not discussed; and there is no explanation of his apparent neglect of ear-training. Although ear-training appears from the title to share equal rights with sight-singing, there are but a few brief references to ear-training, and almost the whole slant of the book is towards singing.

With the exception of a few canons, all the melodies are in one part. None of the melodies were "composed" for this book, but have been drawn from literature and from folk music. I estimate that there must be well in excess of 800 melodies in this book, painstakingly organized under two general divisions, harmony and rhythm. It is possible to isolate almost any conceivable harmonic or rhythmic problem and locate a body of material selected for drill on that specific question. This all represents an enormous amount of labor, for which Mr. Lieberman deserves our most fervent thanks. If only he had provided an index listing each organizational grouping, how much happier we would be! The rhythmical problems are very carefully organized in order of progressive difficulty, if anything, too carefully organized. As the students mastery of the rhythmical material tends to proceed faster than his grasp of the melodic material, the rhythmical problems might have been introduced over a shorter expanse of time. A few purely rhythmical exercises are provided for each new problem in rhythm, which is excellent, as they give an opportunity for concentrated attention on the specific problem involved.

The book is attractively printed, paper covers, spiral-bound. It is unfortunate that the excellent impression that the book makes is marred by a comparatively large number of printing errors in the musical sections. Most of these consist of such things as missing beams and the lack of the numeral "3" within a triplet. In one melody of 16 measures, there are 8 such errors. These will undoubtedly be corrected in a later edition, but are annoying, especially in a sight-singing text. And why, by the way, do not texts dealing with rudiments mention the increasing practice of indicating such metrical divisions by enclosing the affected notes within a bracket, but without a numeral?

The final criteria of a sight-singing book are: an abundance of musical examples, carefully selected and organized in a progressively increasing order of difficulty, and capable of being used with widely differing pedagogical approaches. In these things, this book excels.

CHARLES GARLAND

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THE STUDY OF FUGUE. By Alfred Mann. Rutgers University Press, New Brunswick, N.J., 1958, 341 pp., $9.00.

At last a thoughtful summary of fugal technique has been pro-

duced. This has not been accomplished by any rehashing of the last 150 years' textbook speculation, but simply through the translation and discussion of a few treatises written by men who, living at a time when fugal techniques abounded in practice, were not given to debates on the nature of the "proper" or "examination" fugue or the fugue d'école.

The main body of The Study of Fugue, roughly two-thirds of the text, is devoted to the translation of four treatises. Necessarily they are incomplete. Mann advises us that "certain sections... have been omitted in order to avoid digressions or duplication" although "duplication was not avoided... in places where a comparison of ideas or different approaches to the same thought seemed of particular value." The first translation is from Gradus ad Parnassum (1725) by J.J. Fux. This is not the familiar section on species counterpoint which Mann previously published (W.W. Norton & Co., 1943). It is that section immediately following wherein student and master explore fugal techniques, i.e. imitative exposition, free of the restricting cantus-firmus. Mann's translation of this section, "The Study of the Fugue," first appeared in Vols. 36 and 37 of the Musical Quarterly (1950-51). Friedrich Wilhelm Marpurg's Abhandlung von der Fuge (1753-54) follows Fux. This treatise, the translation of which was made from the 2nd Edition (1806), has been an important source for many textbook authors who have attempted to explain Bach's fugal style. Mann's presentation of this text will be welcomed by those whose teaching of fugue centers around The Well-Tempered Clavier and The Art of the Fugue. Marpurg's text deals with all those subjects with which we are familiar, namely, the theme (subject), the answer, the exposition and development, the counterparts (countersubjects), the episodes, and the various technical procedures, i.e. augmentation, diminution, stretto, etc. His illustrations come from the works of outstanding baroque composers, with a large percentage drawn from the WTC. A complete analysis is made of the Fugue in d minor (WTC II, 6) and the Kyrie from Bach's Missa Brevis No. 4. "Marpurg's discussion of the 'characteristic elements' of fugal technique,... the core of his theory, represents," Mann writes, "the first modern frame of reference for the principles and terminology of fugue."

The latter two treatises will be particularly interesting to those who do not believe that the fugue began and ended with Bach, and particularly valuable to those who believe it did. The Gründliche Anweisung zur Komposition (1790) by Johann Georg Albrechtsberger, Beethoven's teacher, was the basis of Beethoven's studies. Mann has included in the accompanying commentary to this treatise a few of Beethoven's exercises with Albrechtsberger's corrections. Finally, Giambattista Martini, teacher of young Mozart, is represented here by his Esemplare o sia saggio fondamentale prattico di contrappunto fugato, Vol. II (1775). Similarily, Mann has provided an example of Mozart's work with Martini's corrections. The text itself demonstrates both Martini's theoretical and historical orientation. Mann rightly refers to him as the "Mentor of a New Age."

The Study of Fugue is divided into two parts. The translations and commentary occupy the larger second part which, Mann believes, will be primarily of interest to the theorist. Part 1, "The Study of Fugue in Historical Outline," presumably will attract the historian foremost. It would be hoped, as Mann suggests, that no scholar's interests would exclude one or the other of these areas, however. The first part

deals with early fugal theory and subsequently with the contributions of Vicentino, Zarlino and the Last Renaissance Theorists. Morley's Plain and Easy Introduction to Practical Music (1597), Mann believes, "concludes the fugal theory of the sixteenth century and marks the transition to a new epoch." With this, all the elements of the fugal exposition have been assembled and a growing concern for the formal and harmonic operations which concerned the Baroque is implicitly suggested. Ch. II, "The Renaissance: Fugal Exposition," is followed by "The Baroque: Fugal Development" wherein the "Growth of Formal Concepts," the "Progress of Harmonic Thought," and, finally, the "Reconciliation of Linear and Vertical Concepts: Rameau" are discussed. Following Ch. IV, "The Classic Summaries," Mann pits history against the standard textbooks and reveals many of the fallacies which, regrettably, are propounded as truths in many a classroom.

This book is, in reality, a study of the term fuga. It is Mann's thesis that the meaning of this term has not changed. He writes (p. 71):

> The evolution of fugal theory spans six centuries. It shows that remarkable changes have occurred in the concepts of fugal writing. Nevertheless, a line of continuous development can be clearly distinguished which gives the term fuga or its equivalents in the modern languages, a consistent meaning throughout its history.

Thus, it is necessary when reading The Study of Fugue to realize that Mann's use of the terms fugue or fugal apply not just to those meanings which we customarily associate with contrapuntal writing of the Baroque and after, but encompasses all styles wherein the imitative manner is used. The term fugue used so broadly has virtue; yet perhaps, the term fuga might better serve the reader for whom fugue symbolizes the "fugue proper." The "fugue proper" is, of course, anathema to Mann who, rightly, is critical of that non-existing, purely speculative, item known as the "strict," "proper," or "true" fugue. Certainly it is true that some works we call fugues fall "more properly" under the categories of ricercare, etc.; yet, having in mind a something called a "fugue proper," not to be confused with a "proper fugue," it is difficult to apply this term "fugue" as Mann does, to canonic or imitative techniques in renaissance music.

Mann, himself, makes a distinction in his closing remarks to Part 1. After summarizing the baroque fugal development he writes (p. 72):

> With the establishment of harmonic theory, the terms imitation, canon, and fugue found their final distinction. Imitation remained the general term for the casual application of the imitative manner, and canon remained the term for the strict application of this manner; but the term fugue designated the sum of procedures by which the imitative manner was used in order to state and restate, tonally establish, develop, and re-establish thematic material.

It remains that the more general term fuga may easily be supplied by the disturbed reader without jeopardizing the main thesis un-

less, by so doing, one of Mann's principal points is clouded. It is important that anyone who views fugue as a form, which is quite possible wherever the fugue d'école is enthroned, should at least appreciate Mann's view on the matter. Summing up his historical outline, Mann declares (pp. 71-2):

> It has become evident that the term fugue does not apply to a form... It denotes something structurally less concrete. Nor does the term merely apply to a texture... From the very beginning of its use, it has denoted something structurally more concrete.

This is similar to Manfred Bukofzer's declaration that fugue is not a form nor is it a texture but, rather, it is a contrapuntal procedure. As such it has served many forms. Mann's view of the entire span of fugue's history may be summarized thus (p. 6):

> (The) quest for musical structure was associated in all its phases with the term fugue... In its first meaning, it identified the canon, but it was to be used in turn for the motet and its instrumental descendants, the ricercare, tiento, and fantasia. It was applied to the core, and at times to the very essence, of the canzona, of the toccata, and of the overture... It ruled the forms of the Baroque concerto and sonata, and eventually bequeathed the structural achievements which it had gathered during three centuries to the Classic sonata, yet retained its own life in the developmental technique, the "major element" that marked the "final decisive step" toward and beyond the Classic era.

The Study of Fugue, curiously omitted from the review pages of our more popular journals, deserves careful attention. For its major contribution — the translations — we are exceedingly grateful.

DONALD LOACH

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A MEASURE OF TEXTURAL PATTERNS AND STRENGTHS by Quentin Nordgren will propose a series of quantifying techniques in the area of musical texture and will apply these to certain specific musical problems.

A STUDY OF THE HARMONIC THEORIES OF TARTINI by Alejandro Planchart will continue our series of articles on the foundations of harmonic theory in the 18th century. For the first time in the English language, the false mathematical assumptions underlying Tartini's theoretical principles will be carefully examined.

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